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ABSTRACT

This book investigates how workers use computers and how they learn the needed skills, based on a study of 140 occupations in which computers are currently used. Its main finding is that relatively few workers need a lot of computer-related training. Chapter 1, the introduction, discusses the rapid growth and spread of computers across a wide range of occupations, and provides a quick guide to "computerese." Chapter 2 provides advice on the training required for operating or programming computers, along with information on where training is available. Chapter 3, the main body of the book, is a survey of occupations in which computers are used: (1) Group 1, occupations that require extensive computer training, includes professional workers in computer science, and technical workers in data processing; (2) Group 2, occupations that may require training in both programming and operating computers, includes engineers and related technical workers, life and physical scientists, mathematical scientists, and other professional and technical workers; and (3) Group 3, occupations that may require training in operating computers, includes agricultural workers, clerical workers, craft and industrial process workers, managers, professional and technical workers, and sales workers. Appended is a table showing the number of people employed in each of the 140 occupations. (TE)

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GETTING AUSIN THE COMPUTER AGE

The first National Report on the computer skills you need for the job you want

Harold Goldstein and Bryna Shore Fraser
National Institute for Work and Learning

Preface by Willard Wirtz
Chairman of the NIWL

CE

GETTING A JOB IN THE COMPUTER AGE

Harold Goldstein and Bryna Shore Fraser
National Institute for Work and Learning

Peterson's Guides
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Preface

Trying to anticipate the effects of the computer revolution on human employment has become a national preoccupation. Thousands of men and women currently employed in production jobs glance nervously back over their shoulders at the predicted advance of robots. Larger numbers in service occupations wonder whether new equipment about to be installed will make demands on them that they can't meet or will make them redundant. Commentators debate the predicted demise of virtually all "middle-class" jobs.

A related uneasiness pervades the educational and training establishments. Curriculum developers at both secondary and college levels try to assess the changing career needs of students entering an "information age." At what levels should what degrees of computer acquaintance and competence be developed? Should students be offered a variety of computer learning opportunities, or should new components be added to mandatory courses?

Balanced reaction to this situation challenges individual and societal capacities. The change is coming rapidly but with no way to measure its pace or plot its course. Magnifying with an apocalyptic title what others consider semidelirious concern, Christopher Evans sets the 1990s as the decade for the Micro Millenium, when computers will have taken over work so completely that the riddle of the human future will have to be left to them. Realizing that the sale last year of over 2 million commercial- or professional-type computers means that this many additional employees have had to learn new competencies offers firmer suostance for more restrained projections. Fear of the unknown freezes out level-headed calculation of the new opportunities that are the converse side of the prospect.

Goldstein and Fraser introduce into this context some data that seem at first to conflict with these other prognoses but emerge on closer attention as stabilizing facts. Their study of some 140 occupations in which there is evidence of computer usage found that the degree and extent of change in the skill requirements of the vast majority of jobs is much less than has been generally thought.

What they report in no way minimizes the extent to which the computer's widespread use is changing the demand for labor, the content of work, the location of the workplace, and the quality of

working life, as well as the training required for jobs. Analyzing particular occupations and professions—scientists, engineers, programmers, systems analysts, computer testing technicians and repairers—the authors note that the adequacy of education and training in these fields is central to maintaining world leadership in the face of active competition.

Their main conclusion, nevertheless, is that although computer use is widespread and growing rapidly, relatively few workers need—at least so far—extensive education or training in computer-related skills. Although about one in eight workers is found to be using computers in one form or another, most of these are using available software; the necessary skills require only a few hours to a few weeks of training, followed by a period of learning in the course of work. They found that fewer than 1 percent of all workers require long periods of training.

Putting Goldstein's and Fraser's findings beside those that others have emphasized warrants several suggestions regarding the development of perspective in this confused area. One is simply that full account must be given to the critical differences between the kinds of computer skills that are required of, for example, an engineer or a scientist, a programmer, a secretary, and a supermarket clerk pulling coded packages across sensitized scanners. Each of them has the same weight in overall statistics for computer users. Yet the computer skill components of their occupations have almost nothing in common. Lumping them together gives a distorted picture.

Making the distinctions that are required here lessens both the scare elements and in some respects the immediate promise of the "revolution." Young people leaving school without knowing how to use a computer are worrying unduly about their careers being permanently stunted. On the other hand, students and displaced assembly-line workers alike will be properly warned against relying for their futures on learning computer programming—which Goldstein and Fraser find is needed by no more than 2 percent of all workers.

The magnitude of the totals of employees using computers tends to conceal the fact that for the large percentage of these workers computer use is a small component of the job. Training for this component alone won't be enough.

The fact that fewer than 1 percent of all present jobs require extensive computer training leaves entirely open the possibility that well-designed courses to develop computer learning afford a superior opportunity for meeting education's underlying and overriding obligation, which is to teach every student how to think.

equipment manufacturers; some workers get it in schools or in training programs sponsored by professional societies or unions.

The thing to remember is that for most users the computer is a tool for doing the job; the other skills of the job are the important ones—whether you are a secretary, bookkeeper, drafter, engineer, printer, aircraft mechanic, journalist, supermarket cashier, or a worker in any of the other computer-using occupations.

There are a few occupations in which all of the workers need a great deal of special training related to computers. These workers include

- Professional computer programmers
- Computer systems analysts
- Computer repairers
- Programmers of numerically controlled machine tools
- Repairers of numerically controlled industrial equipment
- Teachers of computer science
- Engineers and scientists who design computers

They amount to about 5 percent of computer users and fewer than 1 percent of all workers. The quality of their training is vital to the development of computer technology.

Another 5 to 10 percent of computer users (about 1 percent of all workers) are employed as engineers, scientists, social scientists, accountants, architects, etc. Occasionally some of them find that none of the many computer programs available is exactly suited to their needs, and so they have to be able to write their own. They can start to learn programming by reading a manual, taking a short course of a few days given by their employer or a computer manufacturer, or taking a programming course in a college. The real learning occurs in writing programs. Few become as expert as professional programmers, because they have other professional interests on which they spend most of their time.

All the rest of the workers who use computers—85 to 90 percent of them—simply operate computers with programs that have already been prepared. They learn the computer skills they need with relatively little training. In some cases instruction in the use of the computer is offered as part of the overall training program or educational curriculum for the occupation, as detailed in the individual descriptions of occupations in Chapter 3.

In order to prepare yourself for work in the computer age, you should know exactly what computer skills, if any, might be needed in the occupation you are planning to enter. Then you can decide if you should take computer training in a school and, if so, what kind of

training, or if you can count on getting the training once you are hired.

For example, some workers put information into the computer; others get information out of it; still others have to do both. Word processing is the only work done on computers in some occupations, whereas in others computers are used for calculations as well as word processing or for looking up information. The descriptions presented in Chapter 3 discuss computer use and training in seventy-five occupations. They indicate the kinds of skills needed, as well as whether or not employers expect to provide the necessary training themselves or look for job applicants who already have relevant training or experience. It's important to realize that while it is helpful in some occupations to have a specific computer skill when you are looking for a job, in others the employer is much more concerned about other skills you may have.

Two points frequently emphasized in the many interviews were: (1) for most occupations the computer skill needed is a small part of the total skill requirements and (2) computer operating or programming skills may be introduced in a classroom but are only developed by experience in doing the work.

The first point strongly suggests that if you are preparing for an occupation, your efforts should be directed toward developing all the work skills that will be required. You should not allocate too much time or invest too much money in learning the computer skills alone. Taking secretarial work as an example, a variety of abilities must be developed in order to perform competently; in comparison to many of these, such as language skills, word-processing and other computer skills are learned easily. Similarly, an accountant or an airplane engine mechanic will have had to devote a great deal more time to learning the many core skills of the occupation than to training related to computers.

The second point implies that if you decide to take a computer training course, it would be best to select one that includes substantial periods for practice. This is true whether it is a course in programming (required in a limited number of occupations) or in operating the computer, as in word processing. If instead of taking a formal course you choose to study programming, word processing, computation, information storage and retrieval, or another computer skill from a manual, be sure that you will have access to a computer for periods of time long enough to allow you to practice.

The kind of training you take should, of course, be geared to the kind of work you expect to do. In programming, for example, it is important to learn a computer language appropriate to the

applications you will be working with. In word processing it would save time in relearning if you learn to use a program and equipment similar to what is used in the workplaces where you will be seeking a job.

GROWTH AND SPREAD OF COMPUTERS

Few new technologies have grown as rapidly as the computer or penetrated so many industries in so short a time.

In the 1940s there were only a few large computers in government agencies and universities. By the mid-1980s there were more than 7 million of them, used in every type of business and found in offices, factories, stores, supermarkets, banks, hospitals, and satellites rocketing into space.

Three things have happened to computers at the same time:

- They have gotten smaller.
- Their work capacity has gotten bigger.
- They have been designed to do many different tasks.

These three developments have contributed to the rapidly growing use of computers across a wide range of occupations.

The most common jobs computers do are these:

1. Number crunching: Computers can make many calculations on large arrays of numbers with incredible speed; hence they are used to process statistical surveys like the decennial census of population or to make analyses such as weather forecasts based on information on temperature, pressure, wind direction and speed, and rainfall collected at thousands of locations.
2. Information storage and retrieval: Computers can store and retrieve many records and do calculations on them, and so they are used by such organizations as banks, libraries, insurance companies, and the Social Security Administration for large record-keeping operations; by airlines, hotels, and travel agencies to keep track of space and reservations; by hospitals and pharmacies for patient records; by research organizations to record publications or legal decisions on various topics; and by business firms to keep records of inventory, sales, and production.
3. Repetitive calculations: Computers are used by office workers to carry out regular operations like payrolls, tax computations, billing, and other bookkeeping; by farmers to record such information as what each cow eats and how much milk she gives; by surveyors to make and store measurements and draw maps; and by

foresters to estimate future growth of trees and the lumber yield of forests.

4. Word processing: This application is used not only by secretaries and typists but also by everybody who writes—a category that includes journalists, authors, scientists, and executives—because corrections are made easily, proofreading becomes less burdensome, and if the material is to be printed the type can be set automatically from the word-processing disk or tape.
5. Control of industrial equipment: Computers can be built into industrial equipment to assist designers and draftsmen, to control machine tools as they cut metal, and to control industrial processes such as electrical generation, petroleum refining, and chemical processing. They may be built into industrial robots to guide them as they move materials around in plants or do work on the materials.
6. Graphics: One of the most amazing uses of the computer is to produce graphic designs. The information that creates the designs is digital (that is, a series of numbers); in some cases it consists of mathematical expressions that the computer program translates into lines or curves. An object drawn on the computer screen can be turned around and seen from all sides as if it were a real three-dimensional object. Computer graphics are used by statisticians, industrial designers, drafters, engineers, mapmakers, and the artists who design moving graphics for motion pictures or television, among others. Teachers of mathematics who want to illustrate the characteristics of an equation may use a computer to generate the curve the equation implies.

Examples of Computer Use in Two Industries

The ways in which computers have been adapted to a variety of uses, finding their way into the operations of a large organization, may be illustrated by two examples in quite different industries—airlines and supermarkets.

Airlines

It is no accident that an airline finds many uses for computers, for time is of the essence in this business: flights are tightly scheduled; hundreds of reservations and arrangements must be made simultaneously for travelers who are on the telephone or standing before an airline counter; a pilot in flight needs a rapid flow of dozens of kinds of information on aircraft performance and location.

The following partial list of computer uses was reported by one major airline:

Reservation agents who answer telephone requests use computers to call up information on schedules, fares, and seat availability and to make reservations. Ticketing agents at airports carry out all these functions and write tickets with computers. Passenger service agents use computers to assign seats. Baggage service agents trace lost baggage with them. Crew scheduling is done from computers that tell who is already assigned to work at a particular time and who is available. Computers are also used for weight calculations: airlines need to know the total weight of passengers, freight, and fuel on each flight and the center of gravity of the aircraft. Air freight agents use computers to look up the cost of shipping and to trace freight. The personnel office uses them to keep an up-to-date record of the training each employee has had in order to find qualified employees for assignments. The maintenance staff keeps a service record on each airplane and an inventory of spare parts and orders parts with a computer.

Pilots, while on the ground, use a keyboard to put their flight plans into the flight management computer found on the newest models of aircraft. This calls up from the computer's memory the airports, ground navigation aids, and radio stations en route, as well as the radio frequencies on which flight information is broadcast. Also recorded on the screen automatically is input from instruments measuring speed, altitude, temperature, fuel consumption, and other performance characteristics of the plane. If pilots, while flying, want to simulate a change in flight plan to see if the effects would be desirable, they can enter the proposed plan into the computer with a keyboard and get a reading, while the computer continues to record information on the actual conditions.

Aircraft mechanics use computers to diagnose engine problems and for diagnostic checks of all electronic components; computerized "test boxes" are actually built into the newest aircraft.

Only applications unique to the airline industry have been cited, in each airline there are many other office, management, and professional workers who use computers for word processing, maintenance of financial and office records, calculation, or data storage and retrieval, as do similar workers in many other industries.

Supermarkets

Though the use of computers in supermarkets and grocery stores may seem less pervasive to the casual observer than in the airline

industry, a growing number of operations in the store and behind the scenes are becoming computerized. The main impetus for this is the labor and money savings that result from the increased speed and availability of reports on a number of store operations that previously could not be traced and controlled so accurately.

To the shopper, the most obvious of the supermarket's computerized services and functions is the use of point-of-sale cash registers or scanners at the checkout stands. As of November 1984, a third of the 30,000 supermarkets in the United States had installed scanners, computerized machines that read the price of an item by scanning the universal product code printed on the label.

Less obvious uses of the computer include automated direct store delivery. Sixty-five percent of an average store's 9,000 products come from a central distribution center, but the remaining 35 percent arrive directly from hundreds of vendors who drop off fresh produce, baked goods, dairy products, and other items with a short shelf life. These deliveries may be made as often as every day, and each item has to be checked in and out manually by a clerk. With automated delivery, instead of using paper and pencil, the clerk inventories incoming goods by using a laser gun attached to a portable data entry terminal. This information is then plugged into the computer, and immediate printouts are obtained for matching with the vendors' invoices.

The hand-held, programmable data terminal can also be used for a variety of other applications including produce and meat inventory, causal data collection (factors that may have influenced the sale of an item: was there an in-aisle display? a window sign?), shelf stock audit, and deli/bakery master recipe control (keeping track of changing ingredient costs).

Computers are also used in the meat department to help the butcher get a better yield from cutting. Instead of using a knife in trial and error, butchers use the computer to simulate the cutting that will produce the optimum yield. Butchers can also use the computer to access data on different meat packers to determine which one will help them to offer the best prices. The computer can also be used to maintain prices and records and generate reports for electronic scale systems, such as those used for weighing meat and produce. In addition, the computer assists in perishables management, monitoring the perishable goods in the store to reduce loss.

The computer can print out shelf tags, including the appropriate bar code symbol, as prices are changed, and can determine quickly and easily shelf space allocation (what product gets how much space), using complex mathematical formulas. Computers have been used

for several years to help with energy management systems and to control heating and cooling costs through usage analysis. The computer keeps track of all aspects of employee time and attendance, payroll, and labor scheduling. It also performs scanning data analysis, analyzing the data from the scanners to improve cost controls and enhance store merchandising.

A growing number of grocery stores are using their computers to become part of the Uniform Communications System, which allows for computer-to-computer reordering of groceries. This system eliminates paper purchases and the back-and-forth flow of mail and telephone confirmations. More supermarkets are tying into electronic banking systems, offering their customers the use of automatic teller machines, which grocers see as an opportunity to improve their cash flow.

Some of the larger grocery chains are also offering computerized pharmacies. The computer can keep updated records of a customer's prescriptions, provide prescription records for insurance and tax purposes, advise the customer of problems with existing allergies, and provide immediate warning of potential drug interactions from one or more prescriptions (some machines sound a beeping alarm if two incompatible drugs turn up in a customer's file). The computer can also update drug prices, maintain accounts receivable and third-party billing, and assist in pharmacy management, profit tracking, and inventory control.

Outside the store itself, the computer is used for transportation and distribution center management, vehicle maintenance reporting, and warehousing operations. Some grocers are using computerized storage and retrieval systems in their warehouses for more efficient space management. One large grocery chain, for example, has a software program working off a central computer that knows the "address" of each in-house product and where there are vacancies. Each time a "robo-carrier" guides incoming pallets into the warehouse, computerized cranes lift the pallets into available slots.

As more and more software is developed for use in large and small grocery stores—and this software is proliferating rapidly—it is likely that even more areas of this industry will be introducing computerized operations, affecting the majority of jobs, from cashier to store manager.

This brief review of the use of computers in two industries involving quite diverse technologies and ways of doing business illustrates how computers have been imaginatively adapted to many

different tasks. These are only a few of the uses, and new ones are being developed each day. It is no wonder that computers are used in almost every industry and line of business, by workers in at least 140 different occupations. At the end of 1984 there were 7½ million computers in use, not counting small-capacity home models. In 1984 alone over 2 million new computers were produced, and between 12 and 15 million workers used computers. They are likely to spread to more industries and occupations: there is a computer in your future!

A QUICK GUIDE TO COMPUTERESE

This new technology comes with its own vocabulary, and to understand the information in this book you will have to be familiar with some of these terms.

"Hardware" is computerese for equipment, and "software" is the term for instructions or programs stored in the computer's memory or on disks or tape.

Hardware

There are two principal kinds of computer: digital and analog. Digital computers, the kind most of us are familiar with, function by doing operations on numbers. Analog computers are electrical circuits designed specifically to mimic a process or system: the inputs are continuous variables such as temperature, pressure, or speed, and the outputs are similarly continuous, either graphs on a screen or the movement of controls on industrial machinery.

Either type of computer can be designed to serve as the controlling part of the machinery for an industrial process. Other uses for analog computers include specialized engineering applications. Digital computers that are designed to stand by themselves range in size from mainframes, which can store and rapidly process large amounts of information, through minicomputers to microcomputers, the "personal computers" that have become so popular.

Digital "stand-alones" consist of a central processing unit, which performs operations on data, and various peripheral devices, such as a terminal (a keyboard plus a display device like a television screen), a mass storage unit, a printer, and a modem to communicate with other computers through the telephone system.

Software

The two main kinds of software are operating systems and application programs. Operating systems are designed for specific

models of computers, because they must orchestrate the computer's particular circuits into a state that is ready to accept application programs. They instruct the computer how to do its basic work, using the only language the computer understands, that is, one that indicates whether an electrical element is off or on, which may be expressed as 0 or 1. A binary number system capable of expressing any number can be developed from combinations of 0 and 1, just as a decimal number system can express any number by combinations of the ten digits from 0 to 9.

An application program is a set of instructions that permits a computer to accomplish a specific task. Application programs are inserted into the computer temporarily, as different tasks must be performed. An application program may be either generic, like one of the many word-processing programs on the market, or tailored to meet particular needs, like an airline's reservation system.

Programs can be written in an assembly language, which uses abbreviations and symbols that can be translated into binary by the computer, or in a high-level language, which is closer to ordinary language. Examples of high-level languages are FORTRAN, COBOL, BASIC, FOCAL, and APL. They are made intelligible to the computer by mechanical translation into assembly language. Typically, only computer professionals use an assembly language; most people in other occupations who do programming use one of the high-level languages.

Whereas operating systems must be written in an assembly language, application programs are often written in a high-level language. This is relatively simple, and many users learn to do so or to modify, in minor ways, existing application programs to meet their particular requirements. If the task the program is to accomplish is very large and must be repeated many times, it pays to have the program written by an experienced professional, who can use an assembly language rather than a high-level language in order to achieve more efficiency.

Chapter 2

Computer Training

LEARNING COMPUTER OPERATION

Some workers require only training in operating computers with software already available—this is sometimes called running an application. They include most of the clerical, sales, and industrial process workers who use computers. They can learn their computer skills in anywhere from a few hours to a few weeks of training. Much of the instruction is given on the job or in brief courses provided by the employer, manufacturers of equipment, unions, or schools.

In some cases the computer training is part of a comprehensive training program for the occupation. Such programs may be considerably longer than a few weeks, but only a small part of the time is spent learning the necessary computer skills. For example, the training of library technicians covers many aspects of library organization and procedures, including the classification systems for books and the methods of record keeping for books loaned out; the ways in which computers are used to locate books or control borrowing are an integral part of the training, but the actual operation of the computer keyboard to call up information is a minimal skill in this broader context.

In addition to the brief formal training that is the most common method of learning, an additional period of using the computer on the job is needed in order to perfect the new skills. The speed with which proficiency is attained depends on many factors: the difficulty of the subject matter with which the worker is dealing and his or her familiarity with it; the worker's previous experience and facility with computers; the amount of time the worker spends using the computer (a typist who uses word processing constantly will soon become proficient in this application, unlike a college professor who uses word processing only occasionally to write an article); and whether or not all the computer operations involved in a job are performed regularly (infrequent operations may not be encountered or learned until long after the worker begins using the computer).

Because of these variables and because proficiency means different things in different situations, it is difficult to generalize on the number of weeks or months required to become proficient.

If you are planning to enter an occupation that may entail running an application, it might be helpful to study certain computer-related skills in school, in order to increase your attractiveness to potential employers. One such skill is word processing, which is taught in secondary and postsecondary schools and is useful for secretaries, typists, writers, journalists, and those working in a variety of professional, managerial, and sales occupations. Courses in electronics and computer technology, which are taught in vocational and technical schools and in two- and four-year colleges, provide a good background for such occupations as telephone central office technician, computer operator, and avionics technician (avionics repair is one of the specialties within aircraft mechanics).

LEARNING PROGRAMMING

The programming skills required by those who occasionally have to write computer programs in the course of their work are not nearly at the level of competence required for professional applications programmers, although some may attain such skill levels. These workers are likely to write programs in high-level languages rather than in the assembly languages used by professional programmers to achieve greater efficiency. Because programming is an extra skill for them, subordinate to their main professional interests, few of them have the motivation or the time to spend in developing this skill beyond what they need to get the work done.

Such occasional programmers learn the skill in a variety of ways, including courses lasting a semester or longer in vocational or technical schools or in two-year or four-year colleges, one- to two-week courses (or a series of several such brief courses) given by employers or computer manufacturers, learning from manuals or computer-based instruction, or just learning from friends. College students preparing for these fields frequently take one or more programming courses in the computer sciences department.

The variety of formal training methods may be illustrated by a few examples. One professor of mathematics recommended learning programming by taking a two-semester course involving 3 hours of classroom work each week and 6 hours a week in a microcomputer laboratory; this, he said, would not make a crack programmer but

would help the student get started. Another said that most mathematicians (as distinct from undergraduate students) can learn by reading a manual and starting to program. The Graduate School of the U.S. Department of Agriculture offers a comprehensive eleven-week course to enable people without previous data-processing experience to qualify for positions as entry-level COBOL programmers. A major manufacturer of computer equipment offers a sequence of two 5-day courses designed to enable an inexperienced person who has had college algebra to learn to write FORTRAN IV and FORTRAN 4X programs for the solution of a variety of theoretical problems. Short courses of this sort are offered by a number of computer manufacturers. The difference in class hours between five-day courses and semester-long courses is not as large as at first appears: a five-day course may provide 35 hours, and a one-semester course of 3 hours a week may provide about 45 hours. What does make a difference is that workers who take five-day courses begin to practice programming full-time immediately after training, while students not working in a computer job have to seek out opportunities to practice.

Whatever the method of introductory training, one thing is essential: posttraining experience in programming. This experience may be gained in the laboratory sessions in school courses or while on the job. Learning is made easier if you have someone to turn to for help—a friend, colleague, instructor, or supervisor.

GETTING EXTENSIVE COMPUTER TRAINING

A small but very important segment of the work force requires extensive formal computer-related training. Included are the engineers and scientists who design computers; computer systems programmers who design the operating programs of computers; applications programmers who design the application software; teachers of computer science at colleges and universities; computer systems analysts who design systems for data processing; computer repairers; and programmers of numerically controlled machine tools who write the programs needed for specific machining tasks.

Quite different training programs are required for these various occupations but all of them take several years and usually involve a combination of formal schooling and hands-on training. For example, if you wish to become an electronics engineer who designs computers, you will need to study for an advanced degree from an engineering school. If, on the other hand, you are interested in

becoming an application programmer, you do not need to obtain a degree in computer science, but you will have to take courses in programming, which are available from a wide variety of sources including vocational schools, two- and four-year colleges, and computer manufacturers.

Altogether, the number of jobs that require extensive computer training, while growing rapidly, is relatively small. Adequate preparation for these jobs, however, is critical; the future of our computer technology depends on the availability of high-quality training for all who work in these occupations.

WHERE YOU CAN GET TRAINING

This section will describe the schools and other places where training in computer skills is given, and the kinds of courses they offer. It begins with early levels of the school system, goes on to more advanced levels, and then to employers, computer manufacturers, and other training sources for adults. Remember, however, that even though you may be employed, you can still go to a school for training. In many instances, employers will pay for training offered by one of the other sources described below.

Public Vocational Schools

Computer-related courses are offered at three program levels: secondary, postsecondary, and adult. Participants in adult programs include those already in the labor force who may wish to be retrained or to upgrade their job skills. Classes are usually conducted at local elementary, secondary, or vocational school buildings as well as at community centers. They generally focus on preparation for specific occupations.

Many schools, especially vocational schools, are upgrading their equipment through donations from and partnerships with employers. In addition, computer manufacturers contribute equipment to schools throughout the country. It is very likely, therefore, that computer training courses in a variety of fields will be increasingly available to regular full-time students as well as to adult education participants.

Among the most popular computer-related courses are those in accounting and computing, computer operations, programming, and business data processing.

Noncollegiate Postsecondary Vocational Schools

This group of schools consists of more than 6,000 private and public schools, the majority of which are privately owned "proprietary" schools, including a large number that specialize in business and commercial fields and offer a variety of computer-related courses and programs, such as automation, bank teller training, computer operation, computer programming, systems analysis, business data processing, scientific data processing, electronic office machine technology, keypunch operation, secretarial training, telecommunications, and word processing.

These schools draw from two major groups: recent high school graduates who want to learn specialized vocational skills and adults who want to update or improve existing skills or learn new ones. The schools do not grant degrees. Part-time and full-time courses of study are offered, and training ranges from brief one- to three-day seminars to two-year programs. Classes for the longer programs usually are held five days a week, 5 hours a day. In 1983–84, tuition for a typical ten-month course averaged $2000 at a private school and $800 at a public noncollegiate postsecondary school. Tuition for the shorter seminars, such as those providing an introduction to a specific software program, generally range from $100 to $400 per day at the private schools.

Noncollegiate postsecondary schools maintain a high degree of flexibility in admissions requirements and in courses offered and are generally responsive to local employment needs. In regard to the effectiveness of these schools in training students for actual jobs, however, evidence to date is mixed. Several studies have found that relatively few graduates of professional or technical-level training courses find jobs in the area for which they've prepared. This is particularly true for graduates of computer courses.

Community and Junior Colleges

Two-year colleges, numbering about 1,300, offer many computer-related courses. Because their tuition and fees are generally low (most are publicly supported) and their admissions policies quite liberal, they attract a large number of students from varying backgrounds. Average tuition costs for the academic year 1983–84 were $510 for public two-year colleges, in comparison with $800 for public noncollegiate postsecondary schools and $1270 for public four-year universities. In addition, community and junior colleges often work effectively with local businesses, providing employees with both general programs and training designed to meet specific needs. A

growing number of employers, particularly smaller businesses that do not have an in-house training program, are contracting with community colleges for both custom-designed and general training programs. The majority of these programs involve a small number of employees and are of short duration, ranging from a 1-hour seminar to a full-semester course in such areas as keypunch operation, programming, computer operation, data processing, office automation, management information systems, and data-processing equipment maintenance.

Four-Year Colleges and Universities

Learning how to use computers is being facilitated for many college and university students by increasing ease of access. At many institutions of higher education, computer terminals or microcomputers are located in a central facility for students' use. More and more, students are buying personal computers, the use of which may be shared by friends or roommates. A recent survey by the American Council on Education found that of the freshmen entering state universities in 1983 over one half had written at least one computer program and about one third had taken at least one computer-assisted course in high school.

In 1985 there were nine colleges that required entering students to buy their own computers; seven of these institutions were engineering or technical schools. Many other schools strongly recommend, but do not require, purchase of a computer and have arranged with manufacturers for special discounts for student buyers. Computers are most frequently used on campuses for word processing, but they are also used for calculation, simulation, and interactive learning with appropriate software.

Students may get help in using computers by taking courses in departments of computer science, which typically serve many more students than the number majoring in this field. For those who wish to focus on computer studies, degrees are offered in computer and information sciences, data processing, computer programming, and systems analysis.

Armed Forces

The armed forces provide training in hundreds of specialized occupational skills. Over 95 percent of all Department of Defense (DOD) training is designed to teach new skills to participants; over 55 percent is specialized skill training. The DOD offers over 7,000

different courses, ranging in length from two to twenty-five weeks. Computer-related courses include instruction in computer operation, computer systems analysis, programming, and computer repair and maintenance. The majority of the skills learned in these courses are transferable to civilian occupations—the military has long provided a way for young men and women to get technical training applicable to civilian jobs.

Employers

The clear impression from the interviews conducted in the course of this study is that employers constitute the largest single source of training in computer skills. This impression is confirmed by the 1978 *Survey of Participation in Adult Education*, which found that business and industry provided 38 percent of the computer courses given, in comparison with 27 percent for two-year colleges and 17 percent for four-year colleges and universities, the two next-largest categories. The majority of workers who required training in the use of computers acquired their skills through formal or informal on-the-job training.

One common pattern of providing this training for experienced personnel when new computer equipment is introduced is to give them formal group instruction lasting from a few hours to a week or two and then have them work with the equipment on the job. Support is available when they run into problems. After some weeks or months, the employees "get up to speed."

For new employees the approach has been to incorporate computer training into the total training program for the job, so that some additional hours or weeks devoted to the acquisition of computer skills are built into a program that might take anywhere from a few weeks to more than a year.

In some occupations workers have to be fluent in the use of the computer as soon as they take up their duties (for example, airline reservation agents). For these, the procedure has been to provide a training period long enough for the worker to become proficient before beginning the job.

A wide variety of training methods are used in programs provided by employers. Group instruction is probably the method most widely used. Self-instruction programs using manuals or textbooks are also common. They are sometimes designed for home study but often are for study while on the job; special training facilities may be maintained when the workplace is not conducive to study. Some

companies purchase computer-based teaching materials, including both terminals and videodiscs, for use by employees.

Companies incur costs in providing employees with training in computer skills, like any other training: they pay for the services of instructors and for training materials as well as for the workers' time. Therefore the emphasis is on training geared narrowly to the specific job needs and compressed into a minimum amount of time. In addition, employees are given maximum opportunity to practice the new skills on the job, so that they achieve mastery quickly and effectively.

Company training programs in computer skills may be illustrated by those provided by a public utility in an East Coast city. The utility conducts its own programs, rather than send employees to courses offered by vendors of equipment. Programs of self-instruction have been developed for some groups of workers, including programmers (a three-month training period), members of such departments as engineering and finance who need to learn to use microcomputers (three to five days), and employees who need to learn word processing (two to three days of basics, followed by an advanced course of the same length). Classroom training is provided for employees in departments that do computing on the mainframe computer using terminals; the training is given in two steps—one week of initial training and a second week after the workers have six to twelve months of experience. In this company, systems analysts have normally been moved up from the programming staff after some years of experience.

The company training program of one large manufacturer of computer equipment shows how important this firm considers training to be. Employees average ten days of training per year; although much of the training is concentrated on new workers, the company's policy is to see that all engineers, programmers, and technical writers get five days of training every year. Programming positions, for example, are currently filled by applicants who have had some computer science courses in college; a series of courses is then selected for each programmer by his or her supervisor, who adapts the training to individual needs, so that in the first five years on the job these employees average about fifteen days of training a year in courses three to five days long. Engineers get somewhat less formal training, since they come into the company with degrees in their field that make them productive more quickly; nevertheless, the company encourages engineers to pursue continuing education in order to keep up with their fields, sends them to graduate school with tuition aid, and also gives some university-level training in the

workplace. Salesworkers in this company undertake a long sequence of training, including self-instruction in branch offices; courses in computer concepts and marketing conducted at the company's education center; training in designing a computer system; and a case-study program in which they make calls on customers together with experienced salesworkers and learn to design a computer system for the individual customer.

Most company training programs are a good deal less elaborate. In providing computer-related training, like training in general, it is the large firms that are most active.

Computer Equipment Manufacturers

In addition to training their own employees, manufacturers of computer equipment offer training for employees of companies buying their equipment. There are no statistics on the volume of this training, but our interviews with members of the various occupations that entail computer use suggest that manufacturers are a major source of instruction in the use of computer equipment. Some of the computer manufacturers issue catalogs of courses offered; one of these lists 660 separate courses or training programs. Subjects covered include the operation of computers of various sizes with already-prepared programs, programming, maintenance and repair, systems management, other management problems associated with computers, communications systems, and the operation and programming of equipment for computer-assisted design or manufacturing.

Typically the courses are brief, lasting from one to five days, although some go on for several weeks. They tend to be quite specific, focusing, for example, on a single model of equipment, a single program, or a single programming language. Thus, as a worker's career develops, he or she may need to take additional courses to round out the skills acquired.

Self-instruction is used extensively. Textbooks, programmed learning books, and computer-based training programs are available for many of the subjects. Computer-based programs in such subjects as computer maintenance and repair sometimes use video equipment in order to enable the student to see the equipment being discussed.

Courses are given in training facilities operated by the manufacturers in major cities throughout the country or in the customers' own facilities. Tuition varies widely within the range of about $100 to $400 per day, depending on such factors as expected class size and equipment used. Some courses are furnished without

charge. These include training for a few employees of a customer who has just purchased equipment, and courses designed for executives of firms that are prospective customers on potential computer applications to various areas of business; the latter courses are considered marketing expenses by the computer company.

Professional Associations and Labor Unions

Professional associations and labor unions give courses aimed at advancing the interests of the occupation as a whole as well as enhancing the competence of individual members. They are organized on a national, regional, state, or local basis and have been established for such diverse occupational groups as engineers, real estate brokers, doctors, secretaries, and machinists. In the area of continuing education and training, they serve their members through meetings and conferences, professional publications, workshops, courses, and other educational activities. These activities are almost always part-time and are usually paid for by the participants, their employers, or the union.

These organizations are increasingly offering seminars and workshops, as well as longer courses, in the use of the computer and its specific applications to the particular occupation. As an example, the American Bankers Association, through its American Institute of Banking in New York, offers courses in programming fundamentals, bank data-processing fundamentals, financial planning with an electronic spreadsheet, and bank records management with a microcomputer. In addition, the Institute operates a microcomputer laboratory with an extensive software library for the use of its students.

The American Management Association, National Association of Realtors, and National Shorthand Reporters Association are typical of the diverse professional groups offering their members training in the use and application of the computer in their occupations.

Other Training Sources

In addition to the training activities described above, there are a variety of computer-related programs available through federal, state, and local governments and organizations.

At the federal level, the Job Training Partnership Act (JTPA) and the Trade Act of 1974 are the main sources of funding for training of disadvantaged and dislocated workers. Programs, developed and operated at the state and local levels, are supposed to be designed

with an emphasis on training in fields where job openings are increasing and include secretarial and clerical work and computer sciences, although specific breakdowns of the numbers of workers trained in each area are unavailable.

Since 1980, emphasis in government training programs has shifted toward local partnership programs. These partnerships take a variety of forms but, in almost every case, include the involvement of major employers in the community, in order to ensure that training programs are up-to-date and to provide training in skills needed for current or projected jobs in local industries and businesses.

One example of a major federal computer-related training program is the network of word-processing training centers currently operating in thirty two cities across the country. These centers are run by local community-based organizations in partnership with the IBM Corporation, with additional funding from JTPA. Using up-to-date equipment, they provide training in word processing, computer operation, and computer programming to approximately 3,000 individuals annually. Training is conducted 6 hours a day, five days a week, for twenty-six weeks. Participants are not offered a stipend, but they do receive $35 a week to cover transportation, and other support services, including counseling, are provided.

An example of a state computer-related training program is the Bay State Skills Corporation, created and funded by the Massachusetts legislature in 1981 to act as a catalyst in forming partnerships with business and education to train workers in skills needed by growing industries in the state. The programs range from entry-level training, through employee upgrading, or retraining, to advanced (college- and university-level) programs and run from twenty weeks to twenty months. Training is provided in a wide variety of new and emerging occupations, such as nuclear medicine technology and advanced automation and robotics, as well as in the more traditional occupations of the machine trades, licensed practical nursing, and junior accounting. Community colleges, vocational schools, four-year colleges, universities, and community-based employment and training organizations throughout the state serve as training sites.

In addition to federal and state programs, many local governments and community organizations run low-cost, introductory computer courses, which are offered at libraries, YMCAs, and other community locations. The Tacoma, Washington, Public Library, for example, offers free four- to eight-session classes in computer literacy, programming in BASIC, and selected microcomputer applications. Fairfax County, Virginia, offers a five-session course entitled

Computers for the Medical Assistant; classes are held at night, and costs are minimal.

In summary, a student or worker who wants computer training has a wide variety of providers to choose among. It is likely that employers will continue to provide the greater part of computer-related training on the job, while two-year and four-year colleges and universities increasingly offer training in the use of computers as part of their educational programs.

Chapter 3

Occupations

Group I: Occupations That Require Extensive Computer Training

Professional Workers

Computer Programmers

Programmers write the instructions a computer follows. There are two types of programmers: systems programmers and application programmers.

Systems programmers, working for computer manufacturers, write the instructions for the operating system of a computer. They have to understand the architecture of the equipment and write in assembly language. In this work, emphasis is on designing the program for maximum efficiency, and a high degree of sophistication is required; the best and most creative programmers are assigned to systems programming.

Application programmers, on the other hand, write programs to be used for a special purpose; such programs are fed into the computer on a disk or tape that can be removed so that another application program may be substituted. Application programs may be developed for a single purpose (for example, a statistics-processing program for a statistics collection agency, a sales records and inventory control program for a department store, a flight and reservations recording system for an airline, or a program that will perform a complex scientific calculation), or they may be developed for a general application such as word processing, business accounting, or statistical analysis and marketed to users of computers. Many of the programs used are written not by professional programmers but by members of other occupations who have learned programming.

Application programmers may start with a plan developed by a systems analyst, or they may originate the plan themselves; they then proceed to write the detailed steps that the computer must take to do the work. The instructions to the computer may be written in an assembly language or in a high-level program language, such as COBOL (used for many applications in business), FORTRAN or PL/1 (used for scientific or mathematical applications), or BASIC. Programmers test the completed program, and, when it has been checked out, they also write instructions to the computer operators who will run the program.

There are no standard training requirements for programmers, because employers' needs vary. Courses in programming are offered by vocational schools, community colleges, four-year colleges, and training programs run by computer manufacturers. Colleges and universities offer undergraduate and graduate degree programs in computer science, which prepare students for advanced work and for systems programming. Application programming does not require a degree in computer science; for example, a comprehensive eleven-week course offered by the Graduate School of the U.S. Department of Agriculture is said to "enable people wihout previous data processing experience to qualify for positions as entry-level COBOL programmers." A person already experienced in programming with one language can learn another language in a course as brief as five days, followed by a period of practice in programming with the new language. In an article, "How Workers Get Their Training" (*Occupational Outlook Quarterly* 28[4]:2–21, 1984), M. Carey and A. Eck analyzed data reported in the 1983 *Current Population Survey*, a national survey conducted by the Bureau of the Census. They found that nearly two thirds of the programmers got their training in schools—40 percent in four-year colleges and 19 percent in junior colleges or technical institutes. Informal on-the-job training was reported by 41 percent, and formal employer-provided training by 19 percent. (Note. Some of those surveyed reported more than one type of training.)

For people already employed, one or more brief courses, each followed by intensive experience, has been found to be an effective way of learning application programming. It may take a programmer several months of working under close supervision to be able to handle all aspects of the job, and it takes several years to develop into a really skilled and creative practitioner. Many application programs have been written by people whose main training has been in other occupations; they learn by taking courses in programming, or just by

picking up the skills by experience Some remain in their professional fields, while others go into programming as a full-time career.

To fill positions in application programming, organizations like to hire those who have a strong background in the field for which they will have to write programs. For management or accounting applications, programmers with business school education are preferred; engineering, scientific, and statistical applications also make an appropriate background desirable. This is one reason why members of other occupations have become programmers. In recent years, as college computer science programs have been producing graduates in increasing numbers, employers have been turning to this source for more of their programming trainees.

Computer Sciences Teachers in Colleges and Universities

The members of computer sciences faculties at colleges and universities at one time came into the field from related fields such as physics, mathematics, and electrical engineering. In recent years, several hundred doctorates in computer sciences have been awarded annually, and most new faculty members in university departments of computer sciences have had this training.

The number of Ph.D.'s in computer sciences has not been adequate to the need for teachers in the field. In an effort to meet the demand on an emergency basis, the smaller liberal arts colleges have called upon members of other departments, such as mathematics, to give computer science courses and have paid for training to enable them to do so. In one program, for example, developed under the joint sponsorship of the Mathematical Association of America and the Association for Computing Machinery, eight basic courses in computer science are given for college faculty members in two 8-week summer sessions, and in the intervening academic year participants are required to undertake a complex programming project and to teach one course in computer science.

Computer Systems Analysts

Systems analysts begin with a problem: what does the client want to accomplish? They design a complete system of data processing, including not only what the computer must do and what kind of computer and related equipment is needed but also how data are to

be collected and fed into the computer and how the results of the computer's work are to be produced in such a way as to be useful. The specification for the work designed for the computer itself is then given to computer programmers, who translate the general design into specific instructions to the computer.

While some systems analysts begin as programmers, most enter the field from other occupations, because of the importance of understanding the context in which the system operates. Often their experience is in one of the functional areas of the organization, such as accounting, engineering, office procedures, a scientific field, or statistics, for which computer systems are to be designed. A study of responses to the 1983 *Current Population Survey*, a national survey by the Bureau of the Census, found that two thirds of systems analysts got their training in schools—half of them in four-year colleges—and also that two thirds received training, mostly informal, on the job (M. Carey and A. Eck: "How Workers Get Their Training," *Occupational Outlook Quarterly* 28[4]:2–21, 1984).

In addition to understanding the subject matter of the tasks for which the system is to be designed, systems analysts need to understand data processing and the associated equipment. Courses in computer concepts, systems analysis, and database management as well as some training in applications programming are helpful preparation for this work. Systems analysts need to keep up with constant technological change; from time to time, they have to take short courses offered by equipment manufacturers or software producers on systems management, new equipment, and software. According to the 1984 article in *Occupational Outlook Quarterly* cited above, 21 percent of systems analysts took skill improvement courses in schools, 36 percent received formal training from employers, and 24 percent obtained informal training.

Technical Workers

Programmers of Numerically Controlled Machine Tools

Tool programmers write the programs that direct a machine tool to go through the steps required to perform a specific machining job. Programmers must have broad knowledge of machining operations, blueprint reading, the working properties of various metals, and the use of precision measuring instruments and must have studied mathematics through trigonometry.

Programmers begin with a blueprint of the desired product. They outline the sequence of machine operations required to manufacture the part and then select the proper instructions for the machine, convert the instructions into programming language, and encode the program on paper tape, punch cards, or magnetic tape. The programmer next writes a list of instructions for the machine tool operator. The use of computer numerical control (CNC) equipment, which incorporates a computer, is rapidly replacing the previously mentioned formats, because it provides a more efficient transition from the part at the drawing stage to the machined part.

Employers are inclined to promote or hire skilled machinists to fill tool programming jobs. To learn tool programming, workers take courses at vocational schools, colleges, or community colleges; in some cases, courses are paid for by the employer, in others by the worker. Manufacturers of numerically controlled machine tools provide training for employees of firms that buy the equipment.

The training may be illustrated by a course sponsored by the International Association of Machinists and Aerospace Workers. The course is conducted at a four-year college for a period of 2½ years. Students are in classes for 3–4 hours a week and spend an equal amount of time practicing on computer-controlled equipment. They learn keyboarding; how to write programs in BASIC; CNC coding; computer-aided design and manufacturing (CAD/CAM); and how to write a program to generate points, lines, and circles in languages such as APT (automated programmed tools) or use other computer-assisted programming software. The geometrical description generated is subsequently converted into information needed by the machine tool to produce the part. The interaction of CNC with other process technologies, such as laser welding and electrical discharge machining, is also taught.

Repairers of Data-processing Equipment

These workers are sometimes called computer technicians, customer engineers, or field engineers. The equipment they maintain and repair includes central processing units, terminals, storage units, and printers and the connections between these.

In troubleshooting, the repairer uses instruments such as voltmeters that tell what parts of the equipment are not functioning properly. The newest computers have diagnostic devices built into them or can be plugged into diagnostic equipment, sometimes by

telephone. Repairs can frequently be done by replacing the malfunctioning component.

The basic training required is in electronics, which can be learned in technical institutes, colleges, including community colleges, and the armed forces. More than half the repairers responding to the 1983 *Current Population Survey* by the Bureau of the Census studied in schools, mostly in technical institutes, community colleges, and postsecondary vocational schools; 22 percent were trained in the armed forces; and 60 percent reported getting training from employers (M. Carey and A. Eck: "How Workers Get Their Training," *Occupational Outlook Quarterly* 28[4]:2–21, 1984). Some repairers enter the field after obtaining experience in business machine or television servicing or as engineering technicians. Newly hired repairers usually undergo three months to a year of training, including formal classroom instruction, self-instruction or computer-based training, and on-the-job training. The programs include study of basic electronics and computer theory and circuitry, as well as intensive short courses on the maintenance and repair of specific models of equipment.

In order to learn to work on different models or types of equipment and to keep up with fast-changing technology, data-processing equipment repairers have to keep taking short courses throughout their careers. The study cited above found that more than half reported taking formal company-provided training to improve their skills.

Repairers of Numerically Controlled Industrial Equipment

Those who install and/or repair programmable controllers (PCs) for numerically controlled machine tools or other numerically controlled industrial equipment are experienced electricians who have gone through an apprenticeship or other experienced wiremen who need special training on the characteristics of this equipment.

Training in the installation, programming, and troubleshooting of programmable controllers may be illustrated by a program jointly sponsored and paid for by a local of the International Brotherhood of Electrical Workers and a local chapter of the National Electrical Contractors Association in Los Angeles. The curriculum consists of an 18-hour introductory course, conducted in six weekly 3-hour sessions, on the theory behind programmable controllers, solid-state controls, and how the equipment works; a course of the same duration on programming the PC and troubleshooting; and a 16- to

and build medical instruments and devices, such as artificial kidneys and hearts, cardiac pacemakers, and lasers for surgery, as well as to monitor patients and to build systems aimed at modernizing laboratory, hospital, and clinical procedures. The use of computerized automatic control systems, increasing in chemical plants, petroleum refineries, and electric power generating and distributing stations, requires the engineers to have sufficient competence in computer technology to design systems, supervise their operation, and provide training for plant personnel (National Petroleum Refiners Association: papers presented at NPRA Computer Conference, October 1982). More and more, design work, a major activity of engineers, is performed with the aid of computers.

For practicing engineers, there are a variety of ways in which the necessary computer skills can be learned. Software is available for most of the applications frequently needed, and engineers can learn to use these programs in seminars lasting from one to five days; from there on information in the software manuals and assistance from colleagues or by telephone from the software or computer company are enough to carry them through. Many have become familiar with computers in engineering school, with or without taking special courses. For work beyond what readily available programs can do, some engineers learn to program in one of the high-level languages. Engineering professional societies have comprehensive professional development programs, which offer many short courses. Colleges and engineering schools also give courses for employed engineers. Much of this training is paid for by employers, but sometimes costs are borne by individual engineers who want to improve their skills in order to advance their career or shift jobs.

For those preparing for an engineering career, computer training is becoming more commonly available. Every student must be given appropriate computer-based experience while in engineering school, according to the accreditation standards set for the schools (Accreditation Board for Engineering and Technology, Inc.: *Criteria for Accrediting Programs in Engineering in the United States*, 1984). Students must be able to apply digital computation techniques to appropriate engineering functions, such as problem solving, technical calculations, data acquisition and processing, process control, and computer-assisted design. As examples, mechanical engineering students must obtain substantial experience in computer applications in energy and mechanical systems; industrial engineering students in programming in a high-level language such as Pascal, FORTRAN, or APL, as well as in simulation techniques. Students of manufacturing engineering have to become skilled in the

use of computers and microprocessors in controlling and operating manufacturing systems and in numerical and mathematical modeling; students of petroleum engineering must be able to apply computer skills in upper-level course work.

For students of computer engineering there are, of course, more comprehensive special requirements: a strong mathematical foundation in differential and integral calculus, discrete mathematics, probability and statistics, and either linear algebra and matrices or numerical analysis; engineering science and design courses on hardware, software, application trade-offs, and the basic modeling techniques used to represent the computing process; laboratory experience on logic design, system architecture, operating system software, and interactive computing; and proficiency in programming languages such as Pascal, PL/1, or Ada, as well as understanding of assembly languages.

Engineering Technicians and Technologists

This group of occupations has developed in the area between the crafts and the engineering professions. Engineering technicians and engineering technologists generally work with engineers, assisting them, or they do work requiring a high level of competence but so specialized that a broad engineering education is not needed. Originally these jobs were held either by high school graduates who were self-taught or experienced in working with engineers or by persons who had a partial engineering education. As the occupations and their role have been recognized, formal educational programs have been developed, and the accreditation authorities have identified the kinds of quality and training needed.

The Accreditation Board for Engineering and Technology, Inc. (ABET, Inc.: *Criteria for Accrediting Programs in Engineering Technology*, 1984) has distinguished between educational programs for engineering technicians (two years of postsecondary education leading to an associate degree) and those for engineering technologists (four years leading to a baccalaureate degree). For both levels, the accreditation standards state that it is essential that students acquire a working knowledge of computer usage in engineering technology and that they be instructed in one or more of the high-level computer languages and taught problem-solving applications, as contrasted to traditional data processing—i.e., calculations.

Certain specialties in engineering technology, the standards say, should have appropriate computer-related courses: for example, in industrial engineering technology, simulation robotics, numerical control, and computer-aided design and manufacturing (CAD/CAM); in manufacturing engineering technology, CAM; and in computer engineering technology, programming in high-level and assembly languages, digital logic devices (including microprocessors), and computer architecture systems.

Surveyors and Surveying and Mapping Scientists, Technicians, and Technologists

Surveyors and those in related occupations measure the surface of the earth for a number of different purposes. Land surveyors measure land to establish boundaries for legal purposes or to enable engineers to plan construction. Geodetic surveyors measure large areas of the earth's surface, using special high-accuracy equipment and taking readings off satellites. Geophysical prospecting surveyors identify good places for prospecting for minerals or oil. Marine surveyors survey harbors, rivers, and other bodies of water to determine shorelines, depth, topography of the bottom, and other features. Cartographers use the information collected by the surveys to make maps. Photogrammetrists use photographs taken by satellites to make maps or determine the features of an area.

Electronic distance-measuring equipment embodies computers, as do older instruments such as theodolites, and is used by surveying technicians to measure the distance, direction, and height of each point relative to another point. Surveying technicians require some special training in the use of the computer-modified equipment. The surveyor may use a computer in making calculations and plotting survey information.

The work of the cartographer is changing. Techniques are being developed to permit computer storage of the information generated by surveyors by digitizing it—that is, expressing the lines that describe the features of the earth's surface in coordinates or the altitudes in colors that can be converted into digital information that can be entered into a computer record. Instead of making maps by manually tracing surveyors' original drawings, cartographers will be able to make maps from such digitized information, programming the computer to print out the maps.

Training requirements for surveyors now include the development of skill in using computers for calculating, making measurements,

rainfall, fertilization, tillage, and other factors that come into play during the growing season. The computer is also used in teaching—for example, to simulate the response of an organism to various stimuli, as a substitute for a living animal, or to demonstrate graphically the functioning of an organ or of a whole physiological system. In addition, biological and agricultural scientists use computers for data storage and retrieval and word processing.

The training needed by these scientists varies widely: most computer use involves only readily available software or programs written for a special purpose by a technician or a colleague; but in many cases the scientist has to develop his or her own programs. There is no standard for the computer training required: many students enter graduate school with computer skill already developed; those who need more training select the computer courses they will need in consultation with their faculty adviser and take these courses in the computer science or mathematics department.

Chemists

Computers are used by chemists for a variety of purposes. Only minimal training in the use of the computer is required for such purposes as literature searches (the articles in the most commonly used publication, *Chemical Abstracts*, are now indexed and stored in a computer); word processing; using PROPHET, a graphic system that enables chemists to model and envisage the three-dimensional structure of molecules; and working with computer-controlled instrumentation, such as that contained in magnetic resonance spectrometers.

More extensive training is required for the use of computers in research on molecular structure or reactivity; large-capacity computers are used, and the chemist has to be able to program them in high-level languages, such as FORTRAN, and occasionally in machine language.

Chemistry departments are beginning to recognize that students need more exposure to computers. Courses on such subjects as numerical methods in chemistry are offered in some departments, and chemistry students also take courses in computer science departments. A large number enter college with knowledge of computer use and programming, or learn what they need to by studying on their own. Many of those requiring advanced programming skills for research take the latter route.

The guidelines for undergraduate professional education in chemistry issued by the Committee on Professional Training of the American Chemical Society in 1983 recommend that attention be given to computer applications in the core curriculum, and they list advanced courses in computer science as one of the subjects that meet the minimum requirements for advanced work toward the B.S. degree in chemistry. The committee recommended that students should emerge from an approved program not only with certain training in mathematics and statistics but also with experience with computers, including programming, the use of numerical and nonnumerical algorithms, simulations, data acquisition, and the use of databases for information handling and retrieval (American Chemical Society, Committee on Professional Training: *Undergraduate Professional Education in Chemistry: Guidelines and Evaluation Procedures*, 1983).

Geologists

Geology, at one time considered to be a descriptive science, is employing mathematical methods increasingly, and computers have become valuable to geologists for computation, data storage and retrieval, and mapping. Oil and gas companies, the major employers of geologists, look for job candidates with some computer training. Although software is available for many of the applications needed by geologists, a knowledge of programming in FORTRAN or another mathematics-oriented language is required for some work.

Students who have not acquired programming skills are advised by most geology departments to take one or more courses in the computer science department.

Geophysicists

Geophysicists require a strong background in mathematics and physics. Some use high-capacity mainframe computers in analyzing the shape, structure, and location of the various rock masses underground by means of seismic signals—vibrations made by earthquakes or artificial explosions. They have to be able to program computers for this kind of work—often in machine languages rather than the high-level computer languages used in less exacting programming.

Other geophysicists use smaller computers, often with packaged software, in such activities as modeling or hypothesizing alternative structures underneath the surface, calculating the paths of synthetic seismic signals, and comparing the theoretical results with the data.

Training in computer programming is a normal part of electrical engineering or physics curricula, in which most geophysicists get their training. Three or four courses in computing, including numerical analysis and advanced processing, are required.

Meteorologists

Meteorologists use advanced mainframe computers both in day-to-day weather forecasting and in research. Only a high-capacity computer can keep track of the many and constantly changing measurements (temperature, wind speed and direction, barometric pressure, water surface temperature, precipitation, etc.) made at varying altitudes at thousands of locations. Meteorologists may be able to use prepared software for some statistics and calculations, but they have to do programming for their principal use of the computer.

Although there is no specification for computer training in the qualification standards for meteorologists issued by the federal government's Office of Personnel Management, the standards do call for 20 semester hours in meteorology, including 6 semester hours in forecasting, and this training entails computer programming. The necessary programming skills may be obtained through courses in computer science or self-instruction. The National Weather Service provides focused computer training to its employees, with major emphasis on the requirements of the National Meteorological Center.

Physicists

Both experimental and theoretical physicists may need to use computers in their work. In many cases the requirements for memory and processing speed are so great that only very high capacity mainframe computers can be used. Other physicists, however, are able to use just microcomputers to control their experiments or to do calculations, writing their own programs or using available software such as programs that perform symbolic manipulations.

While some ability to use computers is required of all physics students, training requirements are not uniform. Many have already picked up the necessary skills by the time they begin formal training in physics; those without skills may be encouraged or required to take one or two programming courses in the computer science department or possibly a course offered in the physics department itself.

Mathematical Scientists

Actuaries

Actuaries combine the mathematics of finance with the mathematics of risk—the risk of death, sickness, injury, disability, unemployment, retirement, or property loss from accidents, theft, fire, and other hazards—to manage financial security programs such as casualty insurance, life insurance, and retirement plans. On the basis of their analyses, they make recommendations on plan provisions, price levels, reserve and surplus requirements, and investment policies for each kind of insurance. They conduct research on the persons or properties insured by their companies, using records stored on a mainframe computer. They also do research or modeling on smaller computers or time-sharing terminals, and they may write their own programs for this purpose in such high-level languages as FORTRAN, BASIC, or APL.

Actuaries require a thorough background in mathematics and statistics. Professional qualification is achieved by passing a series of examinations that qualify them as fellows of the Society of Actuaries or the Casualty Actuarial Society. They may learn programming in high-level languages as students or may be given brief (one week or less) formal training by employers, computer manufacturers, or companies that provide time-sharing services on their computers. This is followed by a period of learning while doing, during which they can get help from colleagues or supervisors.

Mathematicians

Mathematicians may use computers for writing, teaching, or research. The most common use is in word processing. In teaching, the computer, with or without graphics, may be used to illustrate a

variety of mathematical concepts, especially in introductory courses in various fields of mathematics. Computers are sometimes used in pure mathematical research; for example, the computer may be programmed to generate sets of numbers from which conjectures about underlying theory may be developed. Newer equipment, together with a symbolic computer language such as LISP, makes it possible for mathematicians to use computers in research involving symbol manipulation. In applied mathematics, the computer's ability to handle large and complex calculations makes it a valuable tool.

To use the computer for these research and teaching purposes, mathematicians have to be able to write programs in a high-level language, such as FORTRAN, Pascal, or a structured BASIC, or in one of the symbolic languages such as LISP. Some learn through college courses in programming; others study on their own, since most computer concepts are understandable to someone with mathematical training.

Statisticians

Statisticians may design and plan experiments or surveys, analyze data already collected, or develop quality control tests for manufactured products.

Computers are used in processing data collected in experiments or surveys and in analyzing data. The computer programs used to process survey data are usually designed especially for the particular survey, most often by computer systems analysts and programmers, but sometimes by statisticians. Generally, statistical analyses of data already collected and processed, by such procedures as seasonal adjustment, measurement of sampling error, tests of significance, index numbers, and correlation, are accomplished with software programs already available and do not require special programming. It is helpful to statisticians, however, to be able to do their own programming or to modify software.

Statisticians can learn to use available software programs in a day or two of training or simply by studying the manual that comes with the software package. Those who have to learn programming do so by taking short courses in programming languages such as FORTRAN, consolidating and extending their knowledge through practical application. Computer courses are required for graduate degrees in statistics.

Other Professional and Technical Workers

Accountants and Auditors

Accountants and auditors examine, analyze, and interpret accounting records for the purpose of advising clients, preparing statements, or installing (or advising on the installation of) systems of recording costs or other financial and budgetary data. These records and systems are increasingly computer based, requiring familiarity with computers and their applications in both accounting and internal auditing.

A bachelor's degree in accounting is required as a minimum by most employers. Virtually all accounting education programs include courses in automatic data processing, as well as computer-augmented accounting, using the computer and packaged software to solve accounting problems. This may involve keyboarding; balance sheets; recording, adjusting, and closing entries; evaluation of inventory; depreciation; bank reconciliation; and computerized payroll systems. The curriculum may also offer an elective in programming (BASIC, COBOL, or another language).

At the graduate level, in such programs as an M.B.A./Certified Public Accountant or M.B.A./Certified Management Accountant, every student is required to take at least one data-processing/management information systems course that teaches techniques for auditing a computerized system. There are only a few degree programs specializing in internal auditing, but nearly all of them require students to learn at least one programming language and to take at least one course in systems analysis. Internal auditors need the equivalent of a minor in computer science and in the application of computers to business in order to judge the effectiveness of the computerized system and its operation as well as the data and processes controlled by the system. An internal auditor must be capable of designing software to test and verify a particular system's controls and to recommend solutions when controls are found to be unreliable.

Because of the rapid proliferation of such computerized information systems, particularly in the last two years, and a shortage of certified internal auditors, many accountants are receiving specialized training in this area through professional associations and outside training organizations; the training is usually paid for by their employers. The Institute of Internal Auditors, for example, offers, at a cost of $700–$800, weeklong seminars in information systems

auditing that include some hands-on experience in using computer terminals and/or microcomputers. Upon completion of the seminar, the auditor is capable of implementing test programs immediately, although it does take some time to adapt to each company's individual system.

Some employers, such as the Big Eight public accounting companies, provide their own training to employees; e.g., Arthur Anderson sends employees to its own school in Chicago for initial training and for continuing education courses.

Single practitioners would be most likely to purchase their own computer and software, mainly electronic spreadsheets, and learn to use them on the job, with little or no formal training beyond any provided by the manufacturer.

Architects

Architects use computers in a variety of ways. Computer-aided design, or CAD—also referred to as computer aided design and drafting, or CADD—is currently used in making architectural drawings, where repetitive work can be more easily done by the computer, using standard software called detail libraries. More advanced software integrates these applications so that changes in drawings are automatically reflected in the specification. Emphasis is beginning to shift from simply replacing repetitive manual tasks with automation to aiding the decision-making process. The computer is also used in making and revising cost calculations and in determining the energy loss and heating costs for buildings of different design. Word processing is used in drawing up contracts and specifications and changing them as needed; software specially designed for writing architectural specifications is available. Computers are also used for office management tasks such as payrolls and for a wide variety of technical applications.

Larger architectural firms introduced computers early; smaller firms have purchased them extensively in recent years, as the microcomputer and software packages for architectural use, such as word-processing programs adapted to writing specifications, became available.

The training needed is primarily that required to use packaged software programs; architects occasionally program new applications.

Training for computer work is quickly becoming a standard part of the five-year Bachelor of Architecture curriculum offered in most schools of architecture or the six-year Master of Architecture curriculum. Training for specific uses, such as word processing, cost calculations, or CAD, is given by equipment manufacturers or software producers in brief programs for employees of firms that purchase computers; training is also offered by software producers or vendors of training. Much training is available in architectural offices via tutorials, instruction books, and audio cassettes. The American Institute of Architects has worked with architects who are expert in the relevant fields in developing a one-day education program on CADD systems and a similar workshop on energy analysis using microcomputers. Those interested in acquiring programming skills to develop new applications of the computer to architecture may do so by independent study or by taking courses in one or another programming language.

Dietitians

Administrative dietitians manage the large-scale planning and preparation of meals in hospitals, prisons, cafeterias, schools, and other institutions. Increasingly, computers and packaged software are being used to order and keep track of inventories of food, equipment, and supplies and to prepare records and reports. Clinical dietitians are responsible for developing and implementing nutrition-care plans and evaluating the results in hospitals, nursing homes, and clinics. They are likely to use computers to keep records on patients' diets and personal nutrition-related data. They would also be likely to use word processing to issue their evaluations and reports.

Over 270 colleges and universities offer bachelor's degree programs for dietitians, and a large percentage of these offer at least one introductory course in understanding the computer and using it as a tool. Some programs include a course in programming language as an elective, which may be particularly helpful to administrative dietitians dealing with large management information systems. The American Dietetic Association, which sets the minimum requirements for becoming a registered dietitian, highly recommends that an introductory course in using the computer be offered to all students and be required of all administrative dietitians.

Elementary and Secondary School Teachers

Because of the increasing attention being focused on computer literacy and the ever-growing number of microcomputers being purchased by school systems throughout the country, the issue of computer training requirements for public elementary and secondary school teachers has come under much scrutiny of late.

In its 1985 report, *Uses of Computers in Education*, Education TURNKEY Systems, Inc., found that computers in schools are being used for computer-assisted instruction, in which the student interacts directly with the computer; computer-managed instruction, in which the computer serves as a support tool; administrative applications specific to the field of education such as keeping attendance records, scheduling classes, and scoring tests; general administrative functions; tool applications/instruction, such as word processing, graphing, and using spreadsheets; and instruction with the computer as its object, including orientation and programming. The report also states that at the elementary level, computers are used most frequently in math, followed by language arts and reading, whereas at the secondary level, computers are used most frequently in computer science, followed by math and business subjects.

Both in-service and pre-service teacher-training programs related to the use of computers are on the rise. Currently, twenty-six states either require or recommend that schools teach their students computer skills, and this in turn leads to inclusion of such skills in teacher training. In a recent survey of state certification offices, two states reported a computer literacy course work requirement for teachers; twelve others reported a planned requirement for teachers. States are requiring not only that new teachers learn basic computing skills before they enter the classroom but also that experienced teachers learn these skills through in-service training.

As a result, a growing number of teachers colleges and schools of education are incorporating into their curricula one or more computer-related courses. They may offer a general introductory course in the use and application of the computer and available educational software or a course that includes study of a programming language (most frequently BASIC or Logo). In addition, student teachers may receive hands-on experience in computer-aided instruction during their teaching internships.

Teachers who are already in the classroom are receiving in-service training in the use of computers for drill and practice, teaching writing skills, word-processing skills, and, in some cases,

programming. Generally, when computers are purchased by, or donated to, a local school system, teachers are given a one-day introductory workshop on how to access the computer and use the software acquired with it. Participation is usually required of all teachers who are given classroom instruction and also obtain hands-on experience with the machine.

In many school systems, in-service training programs (provided and funded by the system) are also offering more advanced courses in using computers. These include learning a programming language (most frequently Logo at the elementary education level and BASIC and Pascal at the secondary level), using a particular software program, and adapting software to meet the individual teacher's needs. Classes are usually conducted after school at a centralized school facility (e.g., the computer laboratory at one of the system's high schools) and consist of group instruction as well as hands-on experience. A typical course may have class meetings once a week for 3 hours over a period of six to eight weeks. Teachers usually receive credit for all courses taken.

Extension Service Specialists

Employees of the Cooperative Extension Service work in the U.S. Department of Agriculture, the land grant universities in the states, and the offices of county agents in farming areas. They use computers in teaching, demonstration, and research, and they train farmers to use them; and some, especially the extension specialists at land-grant universities, write computer programs for use in farm production and marketing management. In many states, each county office has either a microcomputer or a terminal connected to a mainframe computer at the land-grant university.

Many extension service personnel learn to operate computers by studying on their own. Others take courses, such as Introduction to Computers, at land-grant universities or other colleges. Those who do programming have picked it up through self-instruction or have taken courses in the computer sciences departments of colleges.

Foresters and Conservation Scientists

The forester trudging through the woods under a heavy pack may be gathering information destined for entry into a computer. Probably less than half of all foresters and conservation scientists

actually use computers; and only one out of ten of those have to learn programming, whereas the rest can use readily available programs. Foresters use computers for such specialized work as long-range land management planning, as well as for common office functions. For example, they model timber growth, starting with the known stand of trees in an area and estimating growth as well as supply and demand over the next few decades, as a basis for planning cutting. A new electronic communications network with computing capabilities is being installed for the Forest Service, and hundreds of Forest Service employees will need training in its use.

Training in computer work is done by the company installing the communications system; some Forest Service employees are sent to other government agencies or to college programs for training. Most training programs take three to five days, but some are two-week programs. Many of the students coming through college programs in forestry or conservation science in the last few years have already acquired some computer knowledge. Those who have not may take college courses in departments of computer science or mathematics.

Medical Record Administrators

The medical record administrator (MRA) is responsible for planning, designing, developing, evaluating, and managing health record systems to include administrative and clinical statistical data and health records in all types of health-care facilities, organizations, and agencies. The MRA directs the medical records department and develops systems for documenting, storing, and retrieving the information it keeps. These systems are increasingly being computerized, particularly in large hospitals and other large health-care facilities. In some settings, the MRA may be called on to create and develop patient information systems such that the project entails programming or tailoring existing software to the specific needs of the institution, rather than relying wholly on commercially available software packages. In most cases, however, the medical record administrator is not required to do any programming, although a basic understanding of the requirements and limitations of programming is necessary, as is the knowledge of methods for controlling the accuracy and security of the data in computer systems.

Four-year colleges and universities offer bachelor's degree programs in medical record administration that are accredited by the American Medical Record Association and the American Medical

Association. Required computer-related courses include record management, health information management (which contains a word-processing component), management technology (this includes systems analysis techniques and the development and application of quality assurance programs for health record systems), and computers in health care (including evaluation of hardware and software components of computers for health information system applications, data representation and manipulation in computers, requirements and limitations of computer programming, controlling the accuracy and security of computerized data, design and cost-effectiveness of systems, and record linkage and data sharing). Each of these courses also provides either a hands-on clinical experience or a simulated laboratory experience. Graduates of the degree programs are expected to be proficient in all of these areas.

Social Scientists

Economists, sociologists, political scientists, anthropologists, and other social scientists, like other professional workers who write extensively, may use computers for word processing. In addition, they may use them to do statistical analyses or process statistical surveys. Standard software is available for routine statistical analysis, but programming is generally required for some more unusual analysis and for processing surveys.

The computer-related training required for word processing or use of statistical software packages can usually be obtained in a brief formal program followed by a period of learning while working. Many social scientists pick up the skills while in college, with or without formal training.

Social scientists who process statistical surveys or do nonroutine statistical analyses, such as the simulation of systems or the building and manipulation of models (e.g., economic models—equations that represent the ways in which economic variables interact with each other), require training in programming in FORTRAN or other high-level computer languages.

Urban and Regional Planners

Urban and regional planners use computers for calculations, office functions, research, analysis, and the management of geographic databases. For example, they may employ computers for statistical

and other analyses, demographic and economic studies, and modeling in land use or transportation planning or in the solution of such problems as where to build a hospital to serve population concentrations most efficiently. In their offices, planners may use computers for word processing, bookkeeping, and financial management. A computer can be used to store a database of geographic information, and its graphics capability can be applied in mapping, analyzing land use and traffic flows, and other functions. For many of these purposes a microcomputer is adequate, but work with large-scale databases may require the greater storage capacity and more powerful processing capability of a larger computer.

Software is available commercially for some of these uses, but some urban and regional planners encounter cases for which they have to develop their own programs and so must either learn programming or employ the services of a professional programmer.

University departments offering degrees in urban and regional planning generally provide one or more courses on computer use, including a computer methods course and courses in such subjects as statistics, mapping, geographic information systems, or modeling, in which the computer is used as a tool in analysis. By the end of graduate training, the student has learned how to use computers for several purposes. Some students take an additional course in the computer science department or another department at the university in order to learn programming in a high-level language such as FORTRAN.

Group III. Occupations That May Require Training in Operating Computers

Agricultural Workers

Farm Operators and Managers

Computers are being applied in farm management in many ways illustrated in the following examples. Accounts of the farm business can be kept and financial analyses made by means of spreadsheets. The yield of milk from cows can be analyzed in terms of both the quantity and the mix of feeds each cow needs, and a special formula can be developed for each cow or a group of cows. Supplies can be ordered through computer networks. Decisions on risk

management—what crops to grow, the appropriate amounts of fertilizer and insecticides to apply, how much money to invest in equipment, and how much money to borrow—can be made on the basis of yield and price expectations for crops and cost of materials purchased, soil condition, weather, interest rates, and other variables. Farmers can also take computer-assisted courses in various agricultural subjects. Current prices of farm products are available on computerized databases accessible through modems.

Large and midsize farms are more likely to use computers than small farms; about 700,000 farms, or 28 percent of the total, were in the larger-size categories in 1981. According to one estimate, in early 1985 about 8 percent of farmers owned microcomputers or small home models that they used for farm business, and another 2 or 3 percent had access to computers (Holt, 1985). Other estimates of the computer users among full-time farmers range from 5 to 15 percent. Large dairy farms were found to be active users.

A considerable amount of software designed for farm use is available; an inventory of agricultural software lists over 1,700 programs (J. R. Strain and S. Simmons: *The Cooperative Extension Service Update Inventory of Computer Programs,* Institute of Food and Agricultural Services, Florida Cooperative Extension Service, Circular 531-A, April 1984). Several states have centralized computer databases on agricultural subjects and make them accessible to farmers through computer networks. Farmers rarely have to write their own computer programs.

Farmers learn to use computers by participating in brief (one- or two-day) seminars provided by vendors of equipment or software or in agriculture extension service seminars, taking courses at colleges, including community colleges, or studying the manuals that come with equipment or software or the publications of agriculture extension services.

Clerical Workers

Airline Reservation Agents

Airline reservation agents work in large central (home) offices, answering customer telephone inquiries and booking reservations. Each agent uses a computer terminal to obtain information on schedules and to reserve space for passengers.

Although previous travel-related experience with computerized equipment is helpful, it is not required, since all new airline reservation agents, regardless of past experience, must go through the initial training program.

Trainees are sent to a central training facility, where they receive three weeks of classroom instruction, in which about 75 percent of the time is devoted to understanding and using the computer. The fourth week of training is given back in the home office; 20 hours are devoted to using the computer on the job and 20 hours are spent in the classroom dealing with any problems or deficiencies. In the fifth week, trainees are put on a regular work schedule.

During the first three weeks of training, employees are not on the payroll but the airline provides for travel, room, and board. At the beginning of the fourth week, employees start working on a regular salaried basis.

All airline reservation agents receive 1 hour a month of continuation training. Approximately 4 or 5 of these hours over the course of a year are related to the use of the computer.

Bank Tellers

In the course of receiving and paying out money and keeping records of various financial transactions, the majority of bank tellers use computers mainly for storage and retrieval of information from individual and corporate accounts and in some cases for calculating, although separate calculating machines are still in frequent use alongside the computer.

No previous computer experience or training is required; each bank provides its own training program for new tellers. The programs, which last from several days to four weeks, include hands-on experience with the computer. They may be conducted at the work site or at a centralized training location maintained by the bank. Many use compute -aided instruction, so that the tellers are trained largely through interaction with the terminal, although they have the assistance of a supervisor. Simulated transactions enable the trainee to gain hands-on experience prior to beginning work.

Tellers are expected to be proficient in the use of the computer by the end of the training period, although speed increases with several weeks on the job.

Bookkeepers and Accounting Clerks

Increasingly, businesses are using computers to keep systematic and up-to-date records of accounts and business transactions. Bookkeepers and accounting clerks enter information on accounts receivable and accounts payable into the computer as well as review computer printouts for accuracy and completeness. They prepare financial statements, calculate payrolls, record business transactions, and compute interest, rental, and freight charges, using commercially available software. Bookkeepers and accounting clerks also perform word-processing tasks, such as preparing vouchers, invoices, and other financial records. They usually input their own data and use a ten-key adding machine in checking data.

Employers with computerized equipment prefer to hire bookkeepers and accounting clerks who have previous experience or training in data processing and the use of computers. Depending on the size and complexity of the employer's organization, high school courses in principles of accounting together with some hands-on experience in computer operation may be sufficient to qualify candidates for entry-level positions. Additional brief training in the specific hardware and software used by the employer is provided on the job, under the direction of an experienced bookkeeper or an accountant; employees usually master the necessary skills within several weeks.

Other sources of training for these occupations are programs of six months' to two years' duration offered in two-year colleges and proprietary business schools. The two-year A.A. degree in accounting offered by community and junior colleges is designed to prepare students for positions as bookkeepers. In addition to accounting courses, students are required to complete courses in automatic data processing and, in some programs, an introductory course in programming. Completion of the A.A. program is considered very desirable by employers and may enable the degree holder to enter the business in a position higher than entry level.

Cashiers

Working as a cashier—receiving money, making change, filling out charge forms, and giving receipts—is generally an entry-level position that requires little or no previous experience or training, since most employers provide their own training. A rapidly growing

number of cashier jobs, particularly in department stores and supermarkets, involve the operation of electronic cash registers, computerized point-of-sale registers, or computerized scanning systems. Depending on its complexity, a computerized system, such as that often found in a large grocery store, may automatically calculate taxes and change due as well as record inventory numbers and other information.

In a small business, the beginner is usually trained on the job by an experienced worker (this is known as the "buddy system"). After a few hours or a day of hands-on experience, the new cashier is ready to work alone. In large organizations, which are more likely to have computerized registers or scanners, a more formal training course, consisting of classroom instruction and hands-on experience, is likely to be offered. Within supermarkets and grocery stores, which employ the largest number of cashiers, training averages about two days, with at least one day spent learning to operate the register. Larger grocery chains may provide two days of classroom instruction, with much of that time spent viewing films and memorizing product codes, followed by a third day of in-store training on the register; the new cashiers assume regular duties on the fourth day.

Some companies receive training materials free on loan from the equipment manufacturer, while others purchase training programs from private retail training vendors, who offer a variety of materials ranging from 45-minute videotape "seminars" that can be used for beginners or as a refresher course to self-administered audiovisual/workbook combination programs that cover all aspects of a variety of computerized systems and take the trainee 4 to 6 hours to complete.

Although proficiency on simple cash registers may take only a few days to develop, the complexity of many of the computerized systems sometimes means that a period of up to four months is needed for new operators to become expert in their use.

Computer and Peripheral Equipment Operators

Operators work on large computers and associated peripheral equipment. Following the instructions written by programmers, they load the tapes or disks containing the program onto the computer and also load on the tapes or disks containing the data to be processed. They watch the console while the computer is running, to check for malfunctioning, and correct any problems that arise. Peripheral equipment operators do the same for printers and data storage units.

Training for operator jobs is given in technical institutes, community colleges, secondary-level vocational schools, and business schools. However, responses to the 1983 *Current Population Survey* by the Bureau of the Census showed that only one third of the operators were trained in schools (M. Carey and A. Eck: "How Workers Get Their Training," *Occupational Outlook Quarterly* 28[4]:2–21, 1984). A few learn the work while in military service. Others obtain training from computer manufacturers. One major manufacturer provides an eight-day training program for entry-level operators; another offers a four-day program. It is necessary to follow up these short programs with supervised experience. Nearly half the operators in the Census Bureau survey reported having had informal on-the-job training. Since models of computers and peripheral equipment differ, some on-the-job training is always needed, from a few weeks for peripheral equipment operators to several months for computer operators. From time to time, operators need to learn about new equipment or methods, which they can do by self-instruction or taking short courses.

Data Entry Keyers

Once called keypunch operators because they used a small machine to punch holes at the appropriate places in the cards used to feed data into the computer, data entry keyers now more often enter the information on magnetic tapes.

The training required is brief, given in several days. For many jobs typing ability is required. Of keyers responding to the 1983 *Current Population Survey* by the Census Bureau, a third had some training in schools—most commonly vocational courses in secondary schools; more than half got training from their employers (M. Carey and A. Eck: "How Workers Get Their Training," *Occupational Outlook Quarterly* 28[4]:2–21, 1984).

This is one computer occupation for which demand is declining, because of attempts to eliminate or reduce the labor cost required in data entry, as well as the potential for error that creeps in wherever people are involved. In large data systems, data entry is done directly by computer terminals at the site of each transaction (the checkout counter in a supermarket, the sales counter in a store, the charge desk in a library). In others, such as large statistical operations, optical scanning is used to get the information into a record the computer can read.

Directory Assistance Operators

Directory assistance operators use computer terminals to look up and provide telephone numbers. They are not required to have previous computer (or typing) skills or experience. All new operators receive five to seven days of instruction at a centralized training facility maintained by the employer. Training consists of a self-paced course in which the new employee, using a learning guide, takes live calls at the terminal while under the supervision of an instructor (there is one instructor for every two trainees). The trainee learns how to key in the necessary codes to make searches for business, resident, and government listings. By the end of the training period, operators are expected to have an accuracy rate of 80–85 percent; experienced operators are expected to achieve 95 percent accuracy. New operators are monitored by their supervisors during the two to three months following their initial training in order to determine their proficiency and to provide any additional training that may be necessary.

Postal Clerks: Letter-sorting Machine Operators

In large post offices and mail-processing facilities, much of the sorting of letter-size mail is done by postal clerks keying the ZIP code of the letter passing before them. Letters are sorted to an appropriate bin on the back of the letter-sorting machine; they are then pulled from the bin and bundled or sacked for the destination office.

All training for operators is provided on the job by the U.S. Postal Service. No previous experience with computerized equipment is necessary. Each operator receives an orientation to the computerized training system (which is a simulation of the actual letter-sorting machine) as well as the unique keyboard, consisting of two rows of ten keys, each numbered from zero to nine. Operators are allotted 47 hours to train for their first assignment and 32 hours for a subsequent assignment. Training is successfully completed by keying at the criterion speed for the assignment at an accuracy of 98 percent.

During the first forty-five days after qualification, the employee's performance on the letter-sorting machine is monitored by a supervisor in order to ensure proficiency and to determine any keying problem areas. Employees must complete a ninety-day probationary period. After the probationary period, they are continually monitored to ensure at least 95 percent accuracy.

Secretaries

With the introduction of personal computers and such services as electronic mail, the technical skills required of secretaries are shifting from shorthand, typewriting, and operating basic office equipment to such areas as data/word processing; the operation of personal computers, including the use of spreadsheets and software for database management and graphics; telecommunications, including facsimile and electronic mail; and the integration of graphics with other software packages.

According to the 1985 Newspaper Help Wanted Advertisements Survey, sponsored by the Professional Secretaries International Research and Educational Foundation, 30.3 percent of secretarial ads required word-processing/computer skills or the desire to learn them, while virtually all of the ads indicated that typing would be required on the job. Employers are still very much concerned that secretaries have a solid foundation in the more traditional secretarial skills but are increasingly seeking to hire secretaries with experience in automated office equipment.

In an automated office, it becomes the secretary's responsibility to revise and maintain data in spreadsheets as directed by the employer. The secretary also needs an understanding of database management software, since keeping records up to date, as well as adding new records, is largely the secretary's task. In addition, the employer may direct the secretary to produce reports using the information in the database. Secretaries may also be called upon to clean up, proofread, and format correspondence and reports drafted by the employer.

Training for secretaries in the use of automated office equipment is increasingly available from a wide variety of sources. For those not already employed as secretaries, training is available in high schools, proprietary schools, two-year colleges, storefront schools, community organizations, and self-instruction courses. High school vocational education programs focus mainly on general office skills, shorthand, and typing; only a small number of programs offer hands-on experience with word processors or personal computers. Proprietary schools and two-year colleges offer one- to two-year programs in secretarial science, in which approximately one quarter of course time is devoted to the use of computerized office equipment. In 1983–84, tuition for a typical ten-month secretarial course at a proprietary school averaged $2000. whereas annual tuition costs averaged $510 at public two-year colleges. Storefront schools (operated by private training companies) offer a variety of courses in

the use of different computerized equipment and software. The courses typically last from one to three days and devote more than 50 percent of the training to hands-on experience. They may range in cost from $100 to $300 per day, depending on the level and sophistication of training provided. Upon completing a course, students are generally expected to feel comfortable with the system used. The period of subsequent practice needed to attain proficiency varies with the complexity of the system and the individual's adaptation to its use; proficiency in word processing, for example, is usually developed in six to eight weeks.

For secretaries who are already experienced or employed, most of the training on automated equipment is provided at the workplace. New employees with previous experience on computerized equipment are usually given brief on-the-job training by a supervisor, in conjunction with self-instruction and the use of a manual. When personal computers or word processors are purchased by the employer and introduced into the workplace, the equipment manufacturer usually provides a free two- to four-day training program to an agreed-upon number of employees, either in the office or at a centralized training center operated by the manufacturer. (Such training programs are also offered for a fee by private training companies, who may offer programs tailored to the employer's particular needs.) Once training has been completed, employees usually have access by telephone to a support center maintained by the manufacturer. Some large employers operate in-house information centers, designed to provide immediate troubleshooting assistance with both hardware and software. Here again, the speed with which proficiency develops varies considerably with the equipment and the individual, as well as the amount of working time actually spent using the equipment. By the end of two to three months, most secretaries are able to use the computer or word processor comfortably and efficiently.

Stenographers and Shorthand Reporters

In general, the qualifications required of stenographers do not include the ability to use a computer. Employers are usually most concerned that stenographers be fast and proficient in whatever shorthand methods they use.

The exception within this occupational category is the shorthand reporter, a specialized stenographer who records all the statements made in a proceeding. Shorthand reporters are most frequently

employed to record court or conference proceedings. A growing number of reporters are using computer-aided transcription (CAT), a system in which a computer directly translates shorthand notes into ordinary language, greatly reducing the time it takes to produce a transcript. The reporter, using a stenotype machine, makes a verbatim record of the proceedings, feeds the information into a computer, and then edits (or "scopes") the transcript on the video display terminal (although in some cases the transcript is edited by a scopist and not by the reporter). The computer then prints out a complete transcript of the proceedings.

Although the process of becoming a shorthand reporter is initially similar to that of a stenographer—the student must still learn shorthand and how to use a stenograph machine—the use of the computer has led to changes in curricula. Of the two-year training programs in court reporting offered by more than 400 postsecondary schools and colleges, seventy have been approved by the National Shorthand Reporters Association. All of the approved programs either provide training geared to the use of computers or have ordered the equipment to provide such training. Although students in the programs are still taught basic shorthand theory, they learn a form and writing style that are compatible with the computer and switch to using the computer once they have mastered the theory. The students learn how to make a "personal dictionary" for the computer, which stores their individual shorthand outlines and what they stand for, as well as how to compile a "job dictionary," which contains the reporter's shorthand symbols for words and names related only to a particular case or job. The reporter must be able to attain a speed of at least 225 words per minute (wpm) in order to be considered minimally competent, whereas speeds of 120–150 wpm are required of a stenographer.

There are currently seven major CAT systems on the market; the skills learned on one system are generally transferable to the others. Equipment manufacturers also provide the necessary software and brief training in the use of their systems. The equipment (with accompanying training) may be purchased by the reporter (60 percent of shorthand reporters are free-lancers), leased by the reporter from an employer, or owned by the employer (e.g., a court), in which case all costs are assumed by the employer.

For those already in the field, continuing education programs, such as those required by the National Shorthand Reporters Association for certification as a registered professional reporter, include one-day sessions on writing for the computer and management through the computer. How easily reporters become

adept at using CAT depends on how compatible their writing style and basic theory are with the computer. If they are very compatible, proficiency can be attained in as little as a few weeks. If the basic theory was learned long ago and the reporter's writing style is not very "clean," reaching maximum proficiency can take up to a year.

Traffic, Shipping, and Receiving Clerks

The primary duty of traffic, shipping, and receiving clerks is to verify and keep records on incoming and outgoing shipments. Companies employing these clerks are increasingly installing computerized equipment to assist with inventory control and record keeping. These clerical positions are generally entry-level jobs, requiring no previous experience in the use of computers.

Each company provides hands-on training on the job for new employees or employees who must use equipment newly introduced into the workplace. Most of the training generally consists of several hours of learning how to scan labels and product codes by using a wand connected to a hand-held data-processing unit or how to enter a manifest number on a keyboard so that the order can be viewed on a monitor, rather than use pencil and paper. It usually takes about the same amount of time to learn the use of the computerized equipment as it does to learn the old manual system, and clerks generally achieve proficiency within a few days.

Typists and Word-processing Machine Operators

Many employers are still looking for typists with fast and accurate touch-typing skills; however, as more and more businesses purchase personal computers or minicomputers for their offices, a growing number are also requiring word-processing skills or experience when hiring typists. Word-processing machine operators and typists using word-processing software on computers record, edit, store, and revise correspondence, reports, statistical tables, forms, and other materials. They also may operate equipment that extends word-processing capabilities, such as single or multiple printers or optical character readers.

The majority of word-processing training is provided on the job. In many cases, it is learned through hands-on self-instruction, using a manual and the instructional material that is part of most word-processing software. Manufacturers of personal computers and word

developed good general office skills or taken courses in business education. Personnel in these positions generally receive on-the-job training in the use of any computerized office equipment. Brief training in the use of a word processor or a computer software program is usually available from a supervisor or coworker. When new equipment is introduced into the workplace, brief training in its operation is provided by the manufacturer or an in-house trainer, or employees learn through self-instruction. Proficiency is quickly attained by working with the equipment.

Craft and Industrial Process Workers

Aircraft Mechanics

Aircraft mechanics include avionics technicians, who maintain and repair the computer and electronic equipment on the aircraft, and airframe and power plant mechanics. Avionics technicians have to know not only how to maintain and repair computers but also how to use computers for diagnostic checks of electronic components. Computerized "test boxes" are built into the newest aircraft; on older aircraft, the technician attaches computerized testing devices to the equipment like any other electrical instrument. Similarly, the airframe and power plant mechanic uses computers to diagnose engine problems. To use these computerized instruments, mechanics and technicians must be able to attach them properly and read and understand the results. Some new models of aircraft have computerized equipment that continually monitors the performance of many parts of the aircraft and alerts the pilot to malfunctions or gives the mechanic a readout when the aircraft is on the ground. Such equipment reduces the troubleshooting skill requirements for mechanics.

Avionics technicians usually acquire their skills in two-year or four-year college or technical institute programs or in the armed forces; some do so by self-instruction. After being hired, these technicians receive further training from the employer. They may also be sent to training programs maintained by airframe or avionics equipment manufacturers for periods of one to eleven weeks, depending on what they need to learn about the computer and other electronic equipment used on the aircraft. They are given refresher training from time to time, and updating training when new or modified equipment is installed.

Airframe and power plant mechanics need computer training only to be able to use diagnostic equipment on engines. They receive training from airframe manufacturers or airline training departments. These mechanics will, for example, need computer training to work with the new digital electronic engine control system.

Central Office and PBX Technicians

The most advanced central telephone offices have computer-controlled switching equipment—the equipment that enables a caller to connect with the telephone he or she wants to reach by dialing a number. It also records the call for billing purposes. Malfunctions anywhere in the system are spotted by a built-in alarm capability. The alerted technician then diagnoses where the problem is by making some simple checks through the computer terminal, and the malfunctioning part is replaced. Technicians sometimes modify the computer program used to make the diagnoses, but this requires only limited programming skill. More difficult problems are referred to more experienced technicians, and major repairs are done by employees of the equipment manufacturers. The employees doing the more routine maintenance, using computers to diagnose and locate problems, are called maintenance administrators in some companies.

Both the work that the technicians do and the training they need differ among telephone companies. Applicants with technical training in electronics or computers, obtained in a two-year postsecondary school or in the military, are preferred by some companies. Companies formerly in the Bell System give an examination to test employees' technical knowledge, in order to determine work assignments and the training needed by each individual. Training is provided by the employers in the form of classroom study or self-instruction, combined with learning on the job. One company gives ten to nineteen weeks of training over a two-year period; those working on the most sophisticated equipment need only the ten weeks of training. Some employees are sent outside for training provided by equipment manufacturers; one company relies on two weeks of such training, plus on-the-job experience. There is no fixed training period; training systems are flexible to accommodate the different levels of technical education previously attained by employees, different work assignments, and changing technology. After a year or two of training and experience, a technician is able to handle most maintenance problems that arise in a

central office. Rapidly changing technology in this industry necessitates training throughout a worker's career.

Chemical Plant Operators

Continuous-process chemical plants are controlled by computerized equipment that monitors the process: such variables as the heat, pressure, flow rates, levels of liquid, and mix of raw materials are recorded and automatically adjusted when necessary. The operators watch the monitoring equipment, occasionally adjust some of the controls, and stand ready to take steps to avoid breakdowns or upsets in the process. Their responsibilities do not include writing the computer programs.

The training needed by operators depends on their previous experience and on the particular chemical process involved. One chemical company reported giving a few days to two weeks of classroom training to experienced plant workers, followed by one or two weeks of hands-on experience under the eye of a qualified operator. Another gives 280 hours of formal instruction over a fourteen-month period (including the chemistry, physics, and mathematics applicable to the process); 30 percent of the time, or about 80–90 hours, is spent on computer application and instrumentation. The latter training program, given to all chemical operators in the company, is followed by instruction specific to the chemical process the operator will be monitoring. All the training is paid for by the employers and is given on company time.

Electric Generating Plant Operators

Plant operators monitor the operations of the generating plant, using a computer-controlled panel to keep an eye on fuel consumption, temperature, pressure, the amount of power generated, and other aspects of the system. If operators see problems building up that will not be averted automatically by the computer, they intervene to make necessary adjustments or stop the operation of a generator until the problem can be corrected.

Utilities hire candidates with a high school education as trainees for this job; some additional knowledge of electrical or mechanical technology is helpful. Training is given on the job over a period as

use the equipment in anywhere from one day to a week or two, depending on the equipment.

Petroleum Refinery Operators

The computerized process-control equipment in petroleum refineries provides the plant operator with information about the status of the process, including temperature, pressure, flow of fluids and gases, and fuel consumption. The operator uses this information to control the process. In older refineries, the instruments, and, in new refineries, the instruments and control devices are electronically operated. In some cases a supervisory computer is used to control the process automatically, following limits preset by the operator or the computer program.

Training is done on the job. In some cases a computerized simulator training system is used, in which the computer is programmed to simulate various operating problems and conditions, including various upsets or unusual situations that can occur; the operator learns to react to any situation properly (National Petroleum Refiners Association, papers presented at NPRA Computer Conference, October 1982). The use of the computerized control system is only one of many skills that must be learned by refinery operators.

Printing Trades (Graphic Arts) Workers

The printing industry has been profoundly affected by the introduction of computer and other electronics technology, yet very little special computer-oriented training is required or given. Although the most modern equipment has computer controls and/or electronic sensing built in, its use requires no special programming by those working in the industry—the computers are all preprogrammed, and only a general understanding of the principles of computers is needed to use the equipment. Preparation for these occupations is extensive, but it is concentrated on the substantive graphic arts processes, which are complex and require long periods of training and experience.

The use of computers varies, depending on the type of printing process and the size of the plant or the individual printing job. The text to be printed may be typed on computers with word-processing programs, and the type for large jobs may be set up by

phototypesetting machines. The type and illustrations for newspapers, magazines, catalogs, etc., may be combined on pagination equipment (computer-controlled) on which the layout of each page is done. In the production of color illustrations, the color is first separated into primary colors by means of scanners equipped with filters; the intensity of each color at each point on the illustration is then measured and converted into digitized information. Once the information is stored digitally, the skilled operator can change the intensity of each color in any part of the illustration and thus modify the color ultimately printed. Lithographic press plates are made by highly automated machines.

In a large press room, a press console is operated by the senior pressman; built-in monitors control the amount of ink on the plate. The roll feeder also has a small computer unit to monitor and count the feeding of paper into the press, and the paper cutter and folding machine operators have computer and electronic controls to count the sheets and to inform the operators where jams are occurring in the machines.

Preparation for this field is adapted to the particular occupation and printing process, as well as to the needs of the individual and the shop in which he or she is employed. It varies from a six-week program to a four-year apprenticeship, which may be shortened if the employee has previous experience or schooling or learns rapidly. Computer training makes up only a small part of the total; trainees are instructed in the uses of the equipment and acquire a general understanding of the principles of the computer. Operation of the equipment is learned on the job.

Systems Operators or Dispatchers for Electric Utilities

Systems operators or dispatchers control the distribution of electric power over the system—the flow from the various generating plants through the transmission lines to consumers. They also control interchange transactions with other electric power companies, buying power to meet peak loads or to make up for generator outages or transmission line breakdowns, or selling power as it is needed by the other companies.

They monitor the operation of the system, using a computer to keep track of the loads on all lines, the output of generating stations, and equipment or transmission line outages. Operators or dispatchers may need to enter information into the computer.

Generally, they do not program the computer themselves, but they may review new computer programs developed by company programmers and suggest improvements.

Persons with some technical education, such as at least an associate degree in engineering technology, are hired for these jobs. They are trained on the job by a combination of classroom instruction and supervision. Training methods and periods differ among electric utility companies. One may have a two-year training program in which employees receive as much as 16 hours a week in classroom instruction or rotate among related jobs in the company. Another may provide only a few weeks of formal instruction, sometimes including training by manufacturers of the computer-controlled equipment, but a period of several years of informal training on the job.

Managers

Managers and Administrators

Virtually every type of industrial plant, commercial enterprise, and government agency employs managers and administrators whose job is to achieve the objectives of their organization by planning and directing the activities of other employees. Many become managers by promotion from clerical, sales, professional, technical, or craft jobs. They are generally required to have mastered the basic skills within their specific area (e.g., marketing, accounting real estate, finance). Depending on the extent and degree of computerization within their specific organization, they may need to use computers with commercially available software to store and retrieve information about business operations or to do calculations or spreadsheet analyses. In general, if any computer-related training is needed, it is given on the job, and previous education or experience in the use of computers is not required. This is true for such diverse fields as construction project management, hotel management, and fast-food restaurant management. In each of these areas, basic managerial skill and thorough knowledge of the business or trade are still the preferred prerequisites for moving into managerial positions.

Increasingly, companies are hiring graduates of college management programs and those with a master's degree, particularly a master's in business administration, for management trainee positions. Many business schools are currently in the process of revising their curricula to require courses such as an introduction to

computing, which may include the use of personal computers, word-processing programs, spreadsheet analysis, and graphical display of information. In some courses, students also are taught how to design, write, and edit programs, so that the manager will be able to develop specialized programs to fill gaps where existing software does not meet the needs of the organization.

In addition, business schools more and more expect students to use the computer as a tool in many other courses, such as the analysis and operation of inventory systems; electronic data-processing systems; macroeconomics—forecasting and policy; management of information systems; and marketing research and planning. Training in the use of the computer in these areas is particularly important to financial managers, hospital administrators, and middle managers who direct various departments and particular areas, such as personnel, accounting, finance, or marketing.

Professional and Technical Workers

Airplane Pilots

Some of the most advanced models of commercial aircraft are equipped with flight management computers. While still on the ground, the pilot puts the flight plan into the computer, using the keyboard. In flight, the computer continually reports on the aircraft's performance (speed, temperature, fuel consumption and supply, altitude, etc.) and provides navigation information, such as the facilities and navigational aids available en route and the radio frequencies on which navigation information is broadcast. The functioning of the plane's automatic pilot is based on the information that has been stored in the computer. While the computer is carrying out these operations, it can still be used by the pilot to simulate changing the route in order to estimate the effects on fuel consumption, arrival time, and other variables. No programming is needed.

Pilots, who are already highly qualified when they are assigned to training for these new aircraft, go through a training program of several weeks. The program begins with classroom instruction, some of it on the skills needed to use the computer. The pilots then work with a flight simulator, learning to react to signals from the equipment in "real time." After completion of the program, they operate the aircraft under supervision until the supervisory pilot is

satisfied that they are fully competent. The training is paid for by the airline.

Air Traffic Controllers

When an airline pilot files a flight plan, it is recorded on a computer in the Federal Aviation Administration (FAA) traffic control system, and the subsequent progress of the flight or any deviations from the plan are entered into the computer, which thereby has a running record of the flight. When an air traffic controller approves a change in plans, he or she enters it into the computer.

Air traffic controllers are required by law to go through a rigorous training program, including 3½ months at the FAA Academy in Oklahoma City, followed by one of three programs for work in different parts of the system. For work in air route traffic control centers and airport traffic control towers, 20½ additional months of training are required; for flight service station jobs, the additional training period is a maximum of 1,040 hours. Only a small part of the total training time is devoted to learning how to use the computer. Since more than one type of computer is in use in the air traffic control system, controllers may have to learn to use a computer system different from the one they trained on if they take a job in another location. The relatively long preparation is necessary because the controller must be fluent in all job operations before beginning work.

A new air traffic control computer system is under development to supplant the present system, and new training programs will be developed as the new system is put into effect.

Broadcast Technicians

In the electronic environment in which broadcast technicians work, much of the equipment has computerized controls, and, in addition, mainframe or smaller computers are used to monitor and program the sequence and timing of broadcasts. This means that an understanding of computers, the ability to operate them, and the ability to maintain and repair them have to be added to the skills on electronic equipment required of these technicians.

Broadcast technicians in small stations generally perform a variety of duties. In large stations they are more specialized, although job

assignments may change from day to day and they have to have all the job skills. Technicians may specialize in such functions as transmitter operation, audio control, video control, recording, equipment maintenance, and field technical work (setting up equipment to pick up and broadcast an event outside the studio).

A network controls a whole day's log of programs, announcements, commercials, etc., for a" its local stations on a mainframe computer. Local stations have some flexibility as to timing for part of the day's broadcasts so that local material can be inserted. The studio technician controls this on a smaller computer, using a keyboard.

There is no standard training program for broadcast technicians. High school courses in math and science provide a good background, and technical school, community college, or college training in engineering or electronics is good preparation for the field and helps in advancing to supervisory positions. Informal learning in electronics is another channel into the occupation. Four or five years' experience in some of the component skills such as lighting, camera work, and audio or video control helps in getting a studio job. When new equipment is purchased, training of a week or so is given by manufacturers' representatives, either on site or in the manufacturers' training facilities. In addition, technicians get updating training regularly, averaging a few days each per year. Maintenance technicians require more training when hired and undergo periods of training when new equipment is installed; they receive about three times as much updating training, averaging ten to twelve days every year, as other broadcast technicians. In addition to their formal training, all broadcast technicians spend a lot of time reading up on new equipment and new technical information.

Commercial and Graphic Artists and Designers

Moving graphics, such as are used in television broadcasts on the weather or in television and motion picture captions, can be produced on specially designed computer-based equipment. The graphic artist enters instructions with a keyboard or a stylus; drawings or photographs may be entered with an electronic scanner. The computer is programmed to convert the instructions into an animation, in colors, on the computer screen and on tape from which it can be reproduced. Nonmoving designs may also be produced on the equipment.

This work requires, in addition to training as an artist, a few days to a week of initial instruction provided by the manufacturer of the

equipment. The artist then learns by practice, with the assistance of a manual and an occasional telephone consultation; subsequent brief periods of training are usually helpful. In some television studios, a broadcast technician is selected for this training instead of an artist. Learning to produce graphics efficiently may take as long as several months, depending on the individual's aptitudes and abilities and the complexity of the designs.

Drafters

Drafters turn the rough sketches, specifications, and calculations made by engineers, architects, and designers into the detailed drawings to be followed by construction workers or factory workers in making a product. The drawings may show the views from several sides of the building or object to be made and include specifications for the materials to be used, along with other information needed to carry out the job.

Many drafters now use computers with software programs for computer-aided design (CAD). Instead of sitting at a drafting table, they sit in front of the computer terminal and watch the drawing they are punching out on the keys appear on the computer's screen. This may increase their productivity or enable them to make better designs or make modifications to the design easily. Work most frequently done on CAD equipment includes piping, structural, and electrical wiring designs.

In addition to acquiring traditional drafting skills in two-year programs in technical institutes, community colleges, or vocational or technical high schools or through a three to four-year apprenticeship, drafters need specific training in using a CAD software program. Most trainees are drafters with several years of experience, but without previous computer training.

Training in the use of CAD technology may range from two days to three weeks; a common program is five days of training. Some of the initial instruction on new equipment is provided by the equipment manufacturers; some firms do their own training in-house. Thereafter, it may take a CAD operator from two to as long as six months to develop a satisfactory level of skill. Firms have found it useful to conduct continuing training to advance their operators' skills (American Institute for Design and Drafting, CADD Committee: *Report on Survey Made in 1983*, 1984. R. R. Schreiber: The

CAD Operator Today . . . and Tomorrow. In *Manufacturing Engineering*, December 1984, pp. 103–5).

Estimator-Analysts for Electric Utilities

Estimator-analysts estimate, plan, and schedule maintenance and repair work, including major overhauls of equipment such as turbine and generator units. Such units must be put back in service as quickly as possible; therefore the overhaul has to be carefully planned and scheduled. Estimator-analysts use a computer to schedule the work, following "critical path" methods. They track the work hours required for each phase of the job, the work orders issued, and associated costs. They also use computers for related purposes, such as keeping track of the stock of materials on hand.

Workers with maintenance shop experience are desired for these jobs. They are given training in estimating and planning maintenance work as well as critical path techniques. Training in use of the computer for overhaul planning is commonly given in one or two weeks. Employees then learn by working as estimator-analysts. They are provided with software user manuals and receive on-line help from the computer program. If they run into problems they cannot deal with, they can get help from supervisors or specialists. By the time estimator-analysts have gone through one overhaul planning and preparation cycle (five–six months), they have usually become proficient in the use of the computer in this work.

Health Technicians and Technologists

The Committee on Allied Health Education and Accreditation (CAHEA) accredits educational programs for twenty-five allied health occupations. Included are programs for radiologic technologists, who operate X-ray machines or CAT (computerized axial tomography) scans, which give cross-sectional pictures of different parts of the body by a narrow X-ray beam linked to a computer; diagnostic medical sonographers, who use equipment that produces an image from high-frequency sound waves reflected from the body to examine internal organs; and perfusionists, who operate the heart-lung machines used during coronary surgery. Although the majority of these occupations involve the use of highly technical machinery, some of which is computer controlled or computer

driven, the educational programs, ranging from six months to four years, provide training in the operation of a specific piece of equipment rather than in the use of computers. Students would be likely to receive on-the-job exposure to the use of computers for record keeping and patient information storage while they were on clinical rotation during the training period.

No previous familiarity with computers is required of those entering educational programs in these fields, although familiarity with word processing and information storage and retrieval functions may be helpful to students employed by hospitals or other health-care facilities with computerized information systems. This would be particularly applicable to the occupation of medical assistant, since medical assistants perform a variety of administrative (as well as clinical) functions that are increasingly being computerized in physicians' offices, including scheduling and receiving patients; obtaining basic patient data, maintaining medical records; handling correspondence and reports; purchasing and maintaining supplies and equipment; and assuming responsibility for insurance matters and office accounts.

Industrial Designers

Industrial designers use computer-assisted design (CAD) to document their designs, i.e., to translate the initial sketches they have made into precise drawings, usually viewing the object from various angles, each with accompanying dimensions and specifications. The drawings are used by machinists, tool and die makers, or other craft workers to manufacture the product or are fed into numerically controlled machine tools. The design can be modified with the CAD system, which may be operated by a designer or by a technician in the designer's office.

A few weeks to one month of formal training in operating the CAD system by using a computer keyboard is required. The trainee then begins to apply the system in design work and in about six months of steady work usually becomes proficient enough to realize productivity gains over manual drafting. Programming is not required, but some CAD software systems permit the operator to add special applications or shortcuts by using a high-level programming language that is learned relatively easily. The designer using this equipment still needs skills in freehand and engineering drawing as well as in model building.

Lawyers

Law firms today are using computers mainly for word processing, timekeeping, and billing. Particularly for those attorneys practicing in the fields of taxes, estate planning, real estate, bankruptcy, and patent law, the personal computer represents an important tool in the delivery of legal services.

While in law school, almost every student receives some exposure to the use of computerized databases (such as Lexis, DIALOG, and Westlaw), either through a course in legal bibliography or through the use of the database in the school's law library. Law databases contain references to cases that embody precedents in a variety of legal areas; investigation of such cases constitutes the bulk of legal research. Some law schools, currently only a small number, require that all their students receive training in the use of personal computers through specialized computer education courses, whereas other schools expect their students to pick up the necessary skills mainly on their own.

Recent studies of the use of computers within law firms, corporate legal departments, and government agencies have found that large firms with fifty or more lawyers and small firms with fewer than fifteen lawyers are most likely to own and use computers. Despite the belief, expressed by an overwhelming majority of lawyers, that in the next five to ten years computers will be important, perhaps crucial, to the delivery of legal services, the number of lawyers currently using computers themselves appears to be very small (*Lawyer Hiring & Training Report*, July 1984, pp. 1, 16, 17). Most law firms have yet to make formal commitments to integrate the use of computers into their practices. This may be due, in part, to most lawyers' inability to type as well as a lack of software for legal services (although the latter situation appears to be changing rapidly).

In addition, many attorneys do not appear to understand the potential of personal computers and do not want to commit the time necessary to explore possible applications. However, as more software packages come on line and as familiarity with computers becomes more widespread with the entry of recent law school graduates into the marketplace law firms may be compelled to require that their lawyers learn the benefits and uses of personal computers in the delivery of legal services. As the title of a recent seminar offered lawyers by a major management consulting firm puts it, "An Executive Briefing: Computers—Can You Afford Not to Understand?"

Legal Assistants

Often referred to as paralegals or legal technicians, legal assistants perform a variety of duties directly under the supervision of a lawyer. These may include carrying out legal and factual research; interviewing clients and witnesses; receiving and organizing material for cases; preparing estate tax returns, material for probate, and simple wills; and monitoring legislation and federal regulations. Familiarity with the operation and applications of computers in the majority of these task areas, particularly in the preparation of materials by word processing and in legal research, is increasingly important.

Although lawyers will, in some cases, train personnel with relevant legal experience, such as legal secretaries, for legal assistant positions, more and more employers are requiring formal training for these positions. Several hundred programs are offered by a variety of providers: law schools, colleges and universities, proprietary schools, legal assistant associations, and several large law firms. Although most legal assistant programs take two years to complete, they range from intensive, full-time summer programs to programs as long as four years. Depending on the particular program, graduates may receive a certificate, an associate degree, or a bachelor's degree.

Currently, most paralegal training programs do not require that graduates complete a computer-related course, although such courses as Introduction to Microcomputers or Computer Application and the Law are frequently offered as electives. As employers increasingly seek to hire paralegals with computer training or experience, it is very likely that more and more training programs will require that graduates take at least one course dealing with the use of computers, word processing, and litigation and information management.

In addition, some law firms are sending one or more of their legal assistants to daylong workshops, offered by schools and other outside providers, to be trained in the use of computers. These paralegals will then frequently train other paralegals in the firm in the operation and application of the computer in their office.

Librarians

It is projected that by 1990 the majority of medium-sized and large libraries in North America will be automated and that smaller

libraries will have followed suit by the year 2000. Currently, there are about 100,000 libraries in the United States employing 150,000 professional librarians, and there are a growing number of information professionals working in business and industry in jobs managing information storage and retrieval. Among the new technologies affecting the field of library and information service are computers, including microcomputers; word processors; mass storage devices; fiber optics; and videodiscs. On-line terminals for accessing information networks have been one of the most significant advances in library technology of the last decade, and the computer output microfiche (COM) is becoming a common medium of information in libraries. Libraries will continue to have large collections of printed materials, but a significant percentage of statistical and directory data will be accessed through computer terminals, as will almost all bibliographic data.

A master's degree in library science (M.L.S.) is needed to obtain an entry-level professional position in most libraries. Most employers prefer graduates of programs accredited by the American Library Association; in fall 1985, there were fifty-seven ALA-accredited master's degree programs in the United States. Computer technology has become an integrated part of these one- to two-year programs. Almost all include one or more courses on information storage and retrieval, and nearly 75 percent offer courses in library automation, systems analysis, and interactive computer systems. On-line bibliographic citation systems have become so important that instruction in these systems is widely viewed as essential. Programs do vary, however, as to whether such courses are offered as part of their core curriculum or as an elective and whether the courses are theoretical introductions to library automation or more practical, hands-on experiences.

Microcomputer technology continues to shape the pattern of library automation development. As new systems are introduced into libraries, professionals will find it necessary to update their skills. Typically, the vendor of the equipment provides training, either on the job or through short, hands-on courses offered at centralized facilities.

Library Technicians

Also known as library technical assistants, library technicians perform the majority of support activities involved in operating a library. To a growing extent, these activities include retrieving

cataloging information from computer databases and using automated equipment to track circulation, acquisition, and serials activities.

Although some libraries, particularly smaller ones, are willing to train on the job high school graduates with no previous computer-related experience, most are looking for technicians with computer experience or training. Job candidates with an associate of arts degree from two-year college programs in library technology are considered most desirable. Many of these programs now include at least one required course on library automation, designed to give the technician a basic understanding of the roles and uses of the computer. Because there are so many different automated systems used in libraries (for example, there are over 150 circulation systems), courses focus on imparting a general familiarity with library automation, leaving training on specific equipment to be provided by the library where the technician is employed.

Specific on-the-job training may take a variety of forms. When a library purchases computerized equipment (such as an on-line database system), vendor-provided training is built into the purchase price. Generally, a two-week training course is provided at the library by the vendor; trainees spend at least 50 percent of this time using the equipment. Two to three months of constant use of the equipment are normally required to achieve proficiency, for many problems that are not confronted within the training period are likely to arise initially.

Training and the development of proficiency in the use of automated circulation systems usually take less time, although there is considerable variation, depending on the individual's attitude toward the equipment.

Periodic staff development training workshops relating to the use of computerized equipment are offered by many libraries in-house as well as by equipment vendors, private training companies, and professional associations such as the Council on Library-Media Technical-Assistants. A common practice is for a library to send to an outside workshop one staff member who then trains other staff in-house.

Licensed Practical Nurses

Most licensed practical nurses receive no formal instruction in the use of computers during their eight- to twelve-month training period. If computers are used for record keeping or the monitoring

of patients where they work, practical nurses generally pick up the necessary skills on their own on the job, through independent study, or through continuing education courses, which are offered by professional organizations such as the National Federation of Licensed Practical Nurses

Medical Record Technicians

The medical record technician serves as a specially trained, skilled assistant to the medical record administrator, carrying out the many technical activities necessary within increasingly computerized medical record departments. The medical record technician uses the computer to technically analyze and evaluate health records according to standards; compile various types of administrative and health statistics for use in planning and evaluating; code symptoms, diseases, operations, procedures, and other therapies; develop reports on health information; and maintain and utilize a variety of computerized health record indexes and storage and retrieval systems.

In addition, the medical record technician operates word-processing equipment, abstracts discharge data to support quality assurance activities, and supervises one or more health record service activities.

Most employers prefer to hire graduates of two-year associate degree programs accredited by the American Medical Record Association and the American Medical Association. Community and junior colleges offer over eighty such programs, which include 30–40 semester hours of technical course work. Curriculum requirements include courses in word processing, the maintenance and acquisition of health data/information, and the use of computers in health care. These courses are supplemented by either hands-on clinical experience or simulated laboratory experience. Graduates of an accredited program may take a national accreditation examination to become an ART (accredited record technician).

Pharmacists

The last decade has brought tremendous growth in the use of the computer in both hospital and community pharmacy practices. Computerized patient profile systems keep detailed records of patient compliance (e.g., whether patient prescriptions are being

refilled in accord with physician orders), monitor potential drug interactions (some machines sound a beeping alarm if two incompatible drugs turn up in one patient's file), and aid in the calculation of dosages. Pharmacists also employ computers for overall practice management and inventory control. The degree of computerization ranges from the application of the computer to 100 percent of functions to the limited use of personal computers and commercially available software.

Training in the use of the computer is now incorporated into the curricula of all colleges of pharmacy, through hands-on experience in simulated laboratories, the use of computers in conducting required library research, or externships and clerkships in hospital or community practice sites. All graduates of colleges of pharmacy are required to have knowledge of computer applications in pharmacy practice as part of their preparation. Elective courses in the curriculum may offer, through a mix of classroom learning and hands-on experience, training in a programming language and in-depth knowledge of systems design.

For pharmacists already in practice, professional associations, such as the National Society of Pharmacists, offer brief continuing education seminars and workshops on computer systems covering such topics as the evaluation of hardware and software, data file management, the development of patient profile systems, drug interaction systems, and related management systems; participants are commonly provided with hands-on experience. In addition, when computerized systems are introduced into or updated for a hospital pharmacy, the equipment manufacturer provides employees with two or three days of hands-on training in the use of the system for dispensing drugs and keeping patient records.

Physicians

Although computer-based medical education activities are beginning to expand, currently there is little use of computers in required medical courses, with the exception of some computer-assisted instruction and evaluation and a few programs that draw on the computer's ability to model dynamic systems for simulations. Some medical educators appear reluctant to use computers out of concern that the basic medical sciences will be de-emphasized; others simply lack the necessary expertise to introduce computer-based medical education.

system of the firm. Purchasing agents work with systems analysts, informing them of their needs; the system and software are developed by the systems analysts and applications programmers. The computer used is likely to be a mainframe or a minicomputer, which can be accessed through terminals at various places within the company, including the purchasing agent's office.

The National Association of Purchasing Management sponsors educational seminars to assist purchasing agents in determining the information needs of purchasing departments and how they can be met. After such seminars, the purchasing managers can communicate to computer systems analysts the specifics of their problems and needs. Once the computer system is developed, the purchasing agents or managers learn to use the terminals in their offices with minimal instruction.

Registered Nurses

As the use of computers becomes more prevalent in health-care settings, registered nurses are increasingly being required to access computers for a variety of purposes. At present, the most common use is for inputting, storing, and retrieving information on patient admissions, discharges, and billing. More and more, patients' chart information and care plans are being computerized. When this is done, terminals for accessing the files are located at nurses' stations. Some of the most advanced health-care institutions are also beginning to use computers for such traditional nursing functions as monitoring patients and administering intravenous fluids.

Until very recently, training in the use of the computer for registered nurses has been through clinical experience (e.g., working in a hospital with computers) during the course of a two-, three-, or four-year nurses' training program or through brief hands-on training when the equipment is introduced into the health-care facility where the nurse is employed.

Now, however, programs in nursing (particularly the three- and four-year programs) are beginning to introduce training in the use of computers into the curriculum. This is especially true for programs that are affiliated with hospitals committed to rapid computerization. Some nursing programs recommend that their students take an introductory course in computer science as an elective, while others incorporate into existing courses a component on the use of the computer that includes basic knowledge of computer functioning

and instruction in how to access the computer, store and retrieve information, and log off the computer. Some programs require courses that entail computer-aided instruction, in which students are taught how to access the computer and then become familiar with its operation through hands-on experience.

It is likely that within the next five years, most nursing programs will require that graduating students be familiar with the use of computers in health-care settings. Previous knowledge of computers is not currently necessary to enter a nursing program, but familiarity with computers, such as might be gained in an introductory high school class in the subject, is viewed as a distinct advantage for the student.

Reporters and Correspondents

Reporters and correspondents are most likely to use a computer for word processing in the preparation of stories for newspapers, news magazines, radio, or television. There are no requirements for computer skills, and little formal training is offered. Most reporters develop the necessary proficiency through hands-on experience.

Technical Writers

Technical writers describe scientific and technical developments, primarily for insiders who are involved in scientific operations. A technical writer gathers, sifts, condenses, and presents in understandable form the large amount of detailed and often difficult factual information required for reports, articles in scientific journals, instruction manuals for technicians, equipment specifications, contract proposals, and other documents.

Chief employers of technical writers include professional societies, scientific and medical publishers, manufacturers, universities, foundations, federal agencies, and other organizations with research programs.

Educational requirements for technical writing are a bachelor's degree with training in both writing skills and a specialized field such as engineering, business, or one of the sciences. Although master's degree programs in technical writing are available, relatively few people enter this field directly from college. Most technical writers begin their careers by working in other capacities, as, for example,

technicians, scientists, or engineers, and then gradually assume writing responsibilities. Familiarity with computers is increasingly desirable as the use of computers and computer-based equipment becomes more prevalent in scientific and technical fields.

The computer skill useful to technical writers is the ability to access information and use a word-processing program.

Writers and Editors

There are no computer training requirements for becoming either a writer or an editor (technical writers are an exception and are discussed separately). The accepted practice when computer terminals are introduced into a newspaper office, for example, is for everyone using the equipment to be given a very brief word-processing training (of several hours' duration) at the work site and then learn by doing. Within a few weeks, most writers are considered reasonably proficient, even if they are only using two fingers on the keyboard.

Most journalism schools use terminals but do not provide courses in computer operation. Students are expected to pick up the needed skills through hands-on experience.

Sales Workers

Real Estate Agents and Brokers

At present, more than 55 percent of the 115,000 residential real estate firms in the United States are computerized. The majority of those firms that do have computers have "dumb terminals" that are used to access, through a modem, a mainframe computer's automated multiple-listing service for their particular geographic area. The agent calls up the file, views it on the screen, and prints out the listing(s) of interest.

When a new employee is hired, one of the experienced agents trains the new person in how to access the multiple-listing service. This takes no more than a few hours, and no previous experience on computers is necessary.

Growing numbers of real estate agents are purchasing personal computers on their own. Some obtain training in the computer's use from the vendor, outside instructors, or schools; others teach themselves. Software packages aimed at the real estate broker, such

as those for calling up and figuring mortgage and interest rates in terms of monthly payments, conducting searches of recent sales of houses, computing closing costs, and filling out forms and documents, are becoming available for use on personal computers.

Sales Representatives for Computer or Software Manufacturers

The people who sell computers and related equipment, including software, have to have technical and marketing knowledge as well as sales skills.

Many sales personnel enter the field directly from college; a few come with experience in sales or a technical occupation such as engineering, others with experience in an industry or occupation in which there is a potential market for computer applications.

Sales representatives get basic training in computer concepts and marketing, and they learn how to operate minicomputers and how to design computer installations for various purposes. The representatives in a number of computer companies specialize in selling either large or small systems, and some specialize in selling to certain industries, such as manufacturing, finance, retail trade, or utilities.

To keep up with a rapidly changing technology, sales representatives have to take brief courses from time to time to learn about new equipment and the equipment sold by competing firms as well as marketing strategies.

Securities Sales Agents

Securities sales agents have computer terminals on their desks which they may use to find out current prices or other information on individual stocks, bonds, and commodities; general market information; or the status of customers' accounts. The computer is used for information retrieval only; the information is put into the computer's memory by personnel in the company's main office.

These agents need only brief computer training. They may be given a few minutes of instruction in using the keyboard to query the system's memory or asked to read a small manual on how to do this. Such limited instruction may be part of an extensive training program designed to enable new sales agents to meet licensing requirements.

Travel Agents

Almost 85 percent of travel agencies lease computer equipment from one of the major airlines. Travel agents use the equipment for data retrieval and storage as they determine and keep track of modes of transportation, travel dates, costs, and accommodations in planning individual and group travel.

Although previous computer-related training or experience is not required of entrants into this occupation, the larger travel agencies in particular consider it very helpful, especially experience as an airline reservation clerk, since much of the work is similar.

For the training of new employees, each travel agency receives a certain number of training slots from the airline whose equipment it is leasing. The airline pays training, travel, and per diem costs for the agency to send its employees to a central training facility, where they participate in a four-week program, in which two weeks are devoted to the use of the computerized equipment. The larger travel agencies have a policy that all their new employees must be trained through the airline program. If the agency exceeds its allotted number of trainees, it pays the airlines for the cost of training and provides a travel allowance and per diems for the employee. Smaller agencies, on tighter budgets, are more likely to train additional employees on the job.

Although the travel agent is considered functional in the use of the computerized equipment upon completion of the four-week airline training program, up to six months of experience may be necessary for the agent to become totally proficient on the system.

Appendix

The following table shows employment in more than 140 occupations in which computers are used. Both the job titles and the corresponding employment figures were drawn from a more extensive table of occupational data that appeared in the 1984 edition of *Occupational Projections and Training Data,* prepared by the Bureau of Labor Statistics.

The list of occupations included in the table was determined by the authors on the basis of their interviews. In addition, the survey included some occupations for which employment data were not available. For Chapter 3, the job titles used in the table were sometimes replaced by more descriptive alternatives. In the interests of concise presentation, it was also decided to discuss some occupations, such as specializations within the engineering and allied health fields, together in a single description.

In 1982, over 30 million workers were employed in the occupations listed below. They represented about 30 percent of all civilian workers employed in that year. However, in many of the occupations not all the workers are involved with computers; in some, including such large groups as teachers, cashiers, and lawyers, relatively few now use computers. On the basis of the interviews conducted by the authors in 1984–85, it was estimated that roughly 12 to 15 million workers were using computers—about one in eight of all workers in the United States.

Note: Occupational categories that are used in the table to subsume other, more specific occupational titles appear in boldface, as do the corresponding employment figures. The employment figures for the major categories are underscored as well—these add up to the total number of workers employed in occupations in which computers are used.

Civilian Employment in Occupations in Which Computers Are Used, 1982

OCCUPATION	EMPLOYMENT (thousands)
PROFESSIONAL, TECHNICAL, AND RELATED WORKERS	**12,446.3**
Computer specialists	**520.8**
Computer programmers	266.4
Computer systems analysts	254.4
Engineers	**1,204.3**
Aero-astronautic engineers	43.8
Chemical engineers	56.0
Civil engineers	155.4
Electrical engineers	319.5
Industrial engineers	160.2
Mechanical engineers	209.1
Metallurgical engineers	14.0
Mining engineers	5.7
Nuclear engineers	6.3
Petroleum engineers	26.1
All other engineers	208.1
Engineering and science technicians	**1,243.3**
Broadcast technicians	17.1
Civil engineering technicians	35.2
Drafters	302.4
Electrical and electronics technicians	366.2
Estimators and drafters, utilities	6.0
Industrial engineering technicians	27.4
Mechanical engineering technicians	47.8
Surveyors	43.6
All other engineering and science technicians	397.6
Life and physical scientists	**271.0**
Agricultural scientists	21.7
Biological scientists	51.6
Chemists	88.8
Geologists	48.6
Medical scientists	7.2
Physicists	18.8
All other life and physical scientists	34.2
Mathematical specialists	**47.9**
Actuaries	8.2
Mathematicians	10.6
Statisticians	20.1
All other mathematical specialists	9.1
Medical workers, except technicians	**1,986.8**
Dietitians	44.3
Nurses, registered	1,312.4
Pharmacists	151.0
Physicians	479.1

OCCUPATION	EMPLOYMENT (thousands)
Health technicians and technologists	**645.5**
Biochemistry technologists	11.6
Blood bank technology specialists	17.0
Cytotechnologists	4.7
EEG technologists	5.5
EKG technicians	20.9
Emergency medical technicians	5.5
Health record technicians	21.6
Histologic technologists	6.6
Medical laboratory technicians	57.4
Medical laboratory technologists	102.8
Microbiology technologists	8.8
Pharmacy helpers	33.0
Physician and medical assistants	122.9
Radiologic technologists	**110.0**
Radiologic technologists and nuclear medical technicians	36.2
X-ray technicians	73.8
Surgical technicians	34.8
All other health technologists and technicians	82.4
Social scientists	**205.6**
Economists	30.0
Financial analysts	19.3
Psychologists	82.5
Sociologists	5.7
Urban and regional planners	21.4
All other social scientists	46.7
Teachers	**3,656.7**
Adult education teachers	124.7
College and university faculty	744.0
Extension service specialists	13.5
Graduate assistants	139.8
Kindergarten and elementary school teachers	1,366.1
Secondary school teachers	1,024.1
Vocational education teachers	97.9
All other teachers (except dance and athletic coaches)	146.6
Other professional and technical workers	**2,664.4**
Accountants and auditors	855 8
Airplane pilots	79.7
Air traffic controllers	20.9
Architects	84.2
Claim examiners, property/casualty insurance	22.4
Commercial and graphic artists and designers	132.8
Cost estimators	92.4
Designers	179.7
Foresters and conservationists	30.9
Law clerks	40.5

OCCUPATION	EMPLOYMENT (thousands)
Lawyers	464.5
Legal assistants	45.3
Librarians	150.6
Library technicians	29.1
Purchasing agents and/or buyers	176.7
Reporters and correspondents	51.1
Tool programmers, numerical control	12.3
Underwriters	75.8
Writers and editors	119.7
MANAGERS, OFFICIALS, AND PROPRIETORS	**1,622.2**
Sales managers, retail trade	271.5
School administrators	132.8
Store managers	970.5
Wholesalers	247.4
SALES WORKERS	**477.5**
Real estate agents and brokers	337.3
Security salesworkers	78.3
Travel agents	61.9
CLERICAL WORKERS	**14,107.6**
Bank tellers	538.8
Bookkeepers and accounting clerks	1,713.0
Cashiers	1,570.2
Checking clerks	18.6
Circulation clerks	9.5
Claims adjusters	66.0
Claims clerks	66.4
Claims examiners, insurance	47.3
Clerical supervisors	466.7
Court clerks	27.3
Credit clerks, banking and insurance	49.6
Customer service representatives	88.9
Directory assistance operators	37.5
Dispatchers, police, fire, and ambulance	47.8
Dispatchers, vehicle service or work	90.3
File clerks	294.7
General clerks, office	2,348.4
In-file operators	5.0
Insurance checkers	15.0
Insurance clerks, except medical	10.6
Insurance clerks, medical	85.7
Library assistants	81.1
Office machine operators	**806.9**
Bookkeeping and billing operators	227.0
Computer-operating personnel	**579.9**
Computer operators	210.9
Data entry operators	320.0
Peripheral EDP equipment operators	49.0

OCCUPATION	EMPLOYMENT (thousands)
Order clerks	265.2
Postal service clerks	306.5
Reservation agents and transportation ticket clerks	**102.2**
Reservation agents	52.9
Ticket agents	49.3
Secretaries	2,441.5
Service clerks	23.6
Shipping and receiving clerks	364.8
Sorting clerks, banking	7.4
Stenographers	269.6
Stock clerks, stockroom and warehouse	830.9
Transportation agents	20.6
Typists	990.0
CRAFT AND RELATED WORKERS	**624.1**
Aircraft mechanics	108.0
Communications equipment mechanics	91.8
Computer service technicians	54.6
Control room operators, steam	7.9
Power station operators	16.3
Printing trades craft workers	**345.5**
Lithographers and photoengravers	67.3
Printing press operators	173.8
Typesetters and compositors	104.4
FARMERS AND FARM MANAGERS	**1,447.7**
TOTAL EMPLOYMENT IN OCCUPATIONS IN WHICH COMPUTERS ARE USED	**30,725.4**
TOTAL EMPLOYMENT, ALL OCCUPATIONS	**101,510.1**

Source: Employment data from the Bureau of Labor Statistics, *Occupational Projections and Training Data, 1984 Edition*, Bulletin 2206, May 1984, Table B-1, pp. 80–90.

About the authors...

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